Understanding the spread of riparian restoration in the Te Waihora/Lake Ellesmere catchment

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Aminath Nazra

Te Waihora/Lake Ellesmere is New Zealand's fifth largest lake and has significant social, environmental and cultural values. The lake catchment area has been highly modified mainly for intensive farming. There is currently increasing concern for the ecological health and integrity of the Lake Ellesmere and its catchment, due to the increase in land use for residential development and intensive farming. It has been identified that riparian restoration can be beneficial to restore values of the lake and its catchment.

Presently, there are a number of groups in the catchment conducting riparian restoration on margins of lakes and rivers. Waihora Ellesmere Trust (WET) was identified as one such group. This dissertation aims to understand the spread of WET's riparian restoration and uses the diffusion of innovations theory to achieve this aim. Diffusion of innovations theory can be used to explore how the spread of a conservation practice happens in a social system. An exploratory qualitative approach is used to achieve the objectives of this dissertation.

The study found that diffusion of riparian restoration is influenced by several factors. The site selection was influenced by ownership, the location in catchment, ease of accessibility and proximity to other restoration sites. The diffusion process was influenced by the connections in an informal network observed as existing in the lower catchment. Adoption of riparian restoration depended on subjective perceptions of individuals. It was found that a riparian restoration's relative advantage, compatibility with current practices, complexity and observability influenced the rate of adoption of restoration. It was concluded that in this study, cost was identified as the main barrier for restoration. It was evident that funding availability has influenced the diffusion of WET's riparian restoration work.

Keywords: Riparian restoration, Diffusion of innovations theory, Lake Ellesmere Catchment, Innovation, Adoption, Social network, Communication, Conservation practice.

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LIST OF ACRONYMS AND ABBREVIATIONS

CCF	= Community Conservation Fund
CWMS	= Canterbury Water Management Strategy
DOC	= Department of Conservation
ECan	= Environment Canterbury
EEF	= Environmental Enhancement Fund
HTF	= Honda Tree Fund
SDC	= Selwyn District Council
SFF	= Sustainable Farming Fund
SMF	= Sustainable Management Fund
WET	= Waihora Ellesmere Trust

1 INTRODUCTION

New Zealand has a unique biodiversity composed of varied landscapes and indigenous flora and fauna that evolved millions of years ago in periods of isolation (McFadgen & Simpson, 1996). However, the biota has significantly changed since human settlement. It is estimated that over the last 150 years more than 50% of New Zealand's land cover has been converted to grazing land (Collier et al., 1995a). Changes to landscape and the intensification of agriculture have resulted in serious deterioration of aquatic habitats and riparian habitats. In addition, the introduction of exotic species has exacerbated the situation. Weeds have infested majority of these ecosystems and threatened the viability of native plant communities (Saunders & Norton, 2001).

Currently, there are several approaches to restore damaged waterways to a healthy state. Similarly in New Zealand, government agencies, local bodies and community groups have been active in planting native species to restore plant communities and restore the lost habitat of flora and fauna (Wassilieff, 2009). These riparian restoration efforts is one of the ways for sustainable land management through increasing capacity of riparian zones to absorb excess nutrients and filter contaminants before it gets into the waterways (Collier et al., 1995a). In this research, riparian restoration refers to the revegetation of lake and river margins with native plants in order to restore plant communities and restore lost values of these riparian systems.

The Lake Ellesmere catchment is mainly an agricultural catchment with significant biodiversity, social, cultural and economic values (Hughey, Taylor, & Ward, 2008). The lake is described as highly eutrophic and was identified as one of the most impacted lakes of New Zealand in terms of nutrient status (Environment Canterbury, 2009; Verburg, Hamill, Unwin, & Abell, 2010). It was identified in the Waihora/Ellesmere Living Lakes Symposium 2007, that riparian restoration would be beneficial to the values of the lake and its catchment (Waihora Ellesmere Trust, 2009a). Similarly, the need for riparian restoration is emphasised in the Canterbury Water Management Strategy (CWMS). The restoration of waterways and protection of the biodiversity is identified as one of the initial steps in achieving targets of the strategy (Canterbury Water Management Strategy, 2010). The strategy noted that in the long-term restoration and protection will become a pre-requisite for new or reconfigured development.

There is a need to examine the existing riparian restoration programmes in Canterbury. This dissertation was developed in anticipation that a better understanding of such programmes

would be gained and it was hoped that this will contribute to the development of future riparian restoration programmes.

1.1 RESEARCH AIMS AND OBJECTIVES

This dissertation explores riparian restoration initiatives in the Lake Ellesmere catchment, Canterbury, New Zealand. The main aim of this study is to gain an understanding of spread of riparian restoration practice in the catchment through finding solutions of 'how' it spread and 'why' it is spreading. The diffusion of innovations theory will be used to gain an insight to the spread of restoration initiatives. The focus of the study will be on riparian restoration work of Waihora Ellesmere Trust (WET).

The specific objectives of this research are:

1. Compilation of data on the WET's riparian restoration sites
2. Exploration of the 'life history' of the riparian restoration sites (that is how these sites evolved).
3. Develop an understanding of how WET's riparian restoration initiatives have spread among the community of the catchment using the diffusions of innovations theory.

1.2 OUTLINE OF DISSERTATION

This dissertation is presented in seven chapters. The first chapter gives an introduction to the study discussing its purpose and significance. It also outlines the main aim and objectives of this study. Chapter two provides a background to the various concepts described in the study, mainly the diffusion of innovations theory and riparian systems. This chapter also provides a background to the Lake Ellesmere and its catchment focussing on why riparian restoration is required for that catchment. Chapter three initially reviews the literature on the diffusion of innovations theory and riparian restoration. It concludes by exploring available literature on the use of diffusion of innovations theory in the spread of conservation practices. Chapter four describes the methodology used for data collection and analysis. Chapter five presents the results of the study. Chapter six discusses these results in the context of the literature review and explores the use of diffusion of innovations theory in riparian restoration. The dissertation concludes with chapter seven summarising the findings of the study and discussing recommendations for future research.

2 BACKGROUND

2.1 DIFFUSION OF INNOVATIONS THEORY

Diffusion is the process through which an innovation spreads within a social system through channels over time (Lundblad, 2003; Rogers, 2003). An innovation can be an idea, a practice or an object which is thought as new by person/people adopting it (Rogers, 2003). The newness of the innovation is the perceived newness to the adopter and it could have existed for awhile before adoption/rejection (Rogers, 2003). It becomes an innovation when the adopter perceives it as "new" and this can be expressed in terms of knowledge, persuasion or decision to adopt (Rogers, 2003; Tan, 2003). For example, the prevention of scurvy as an innovation was only adopted 85 years after the discovery of the knowledge of the role of Vitamin C in its control (Rogers, 2003).

Rogers (2003) identifies four main elements that are identifiable in all diffusion studies or programs. The four main elements are the a) innovation, b) communication channels, c) time and d) social system. An innovation is adopted quicker if it has a relative advantage, if it is compatible with current practice, if it is trialable and also if it is less complex. The information about an innovation can spread through media or interpersonal channels. Time is of essential as it is involved from the time a person gets informed about the innovation to the time person rejects or adopts the innovation. In order to understand the diffusion process, the norms, values and characteristics of the social system which it flows through must be understood.

2.2 RIPARIAN RESTORATION

Riparian systems are areas of interactions with the terrestrial and aquatic ecosystems (Gregory, Swanson, McKee, & Cummins, 1991). The riparian zone usually extends from edges of water bodies to edges of upland streamside vegetation (Gregory et al., 1991; Naiman, Décamps, & McClain, 2005). Figure 1 shows an example of a stream and its riparian area with the different geomorphic zones. These systems form networks within the catchments (Naiman et al., 2005).

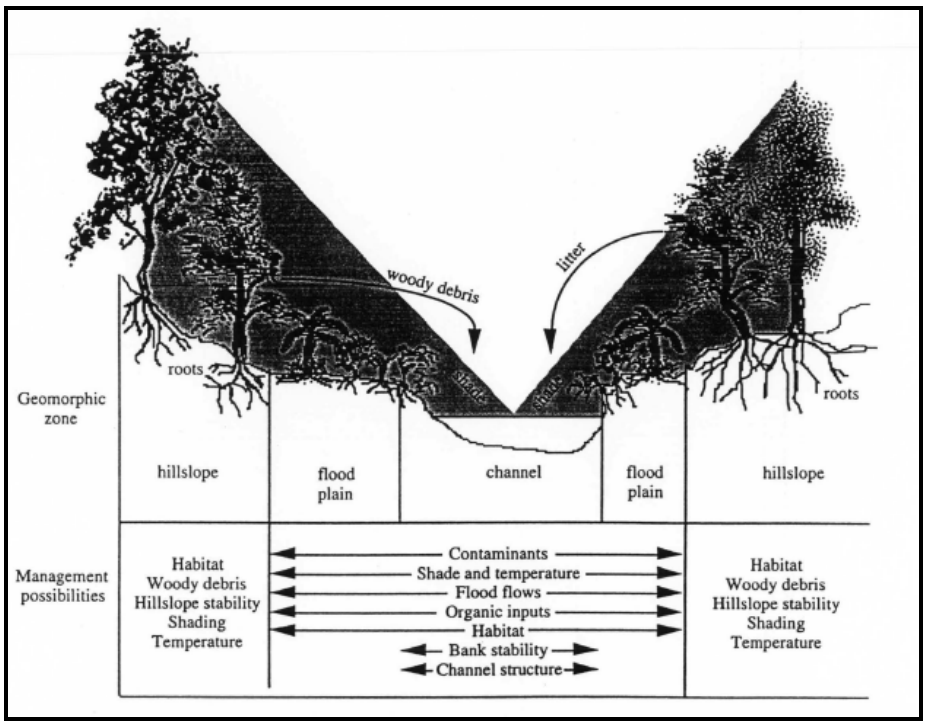

Figure 1 Conceptual diagram showing the stream and its riparian area with its geomorphic zones and management possibilities (Collier, 1995).

Riparian systems are highly active environments with strong energy regimes; diverse plant communities, environment gradients and ecosystem processes (Gregory et al., 1991; Naiman et al., 2005). Because of this unique physical and dynamic environment, riparian systems offer valuable functional services (Naiman et al., 2005). These include economical, social, and biological values (Table 1). In addition, cultural values are as important. For example, Lake Ellesmere in New Zealand is a tribal taonga for Ngāi Tahu and the catchment area is a source of major mahinga kai (defined in the Te Waihora joint management plan as "customary gathering of food and natural materials and places where those resources are gathered") (Department of Conservation & Te Rünanga o Ngäi Tahu, 2005).

Table 1 Values of riparian systems (Malanson, 1993).

Economic Values	Social Values	Biological Values
› reduce downstream flooding › high yield of timber › recharge aquifers › surface water supply › support secondary productivity (e.g. fisheries)	› recycle nutrients, tighten spiral and storage › store heavy metals and toxins › intermediate storage for sediments › natural heritage › natural laboratories for teaching and research › recreation › aesthetics	› special habitat for some endangered or threatened species › refugia for upland species › corridors for species movement

Humans have been using these riparian systems because of their economic, social and cultural values for a long time (Norris, 2001). However, human use has often degraded riparian systems (Davis & Meurk, 2001). Grazing and urban development are the main causes of this degradation. Human relationship with the riparian environments is interrelated with its natural cycle (Figure 2). An integration of both natural and human-cultural factors is essential for management of riparian systems.

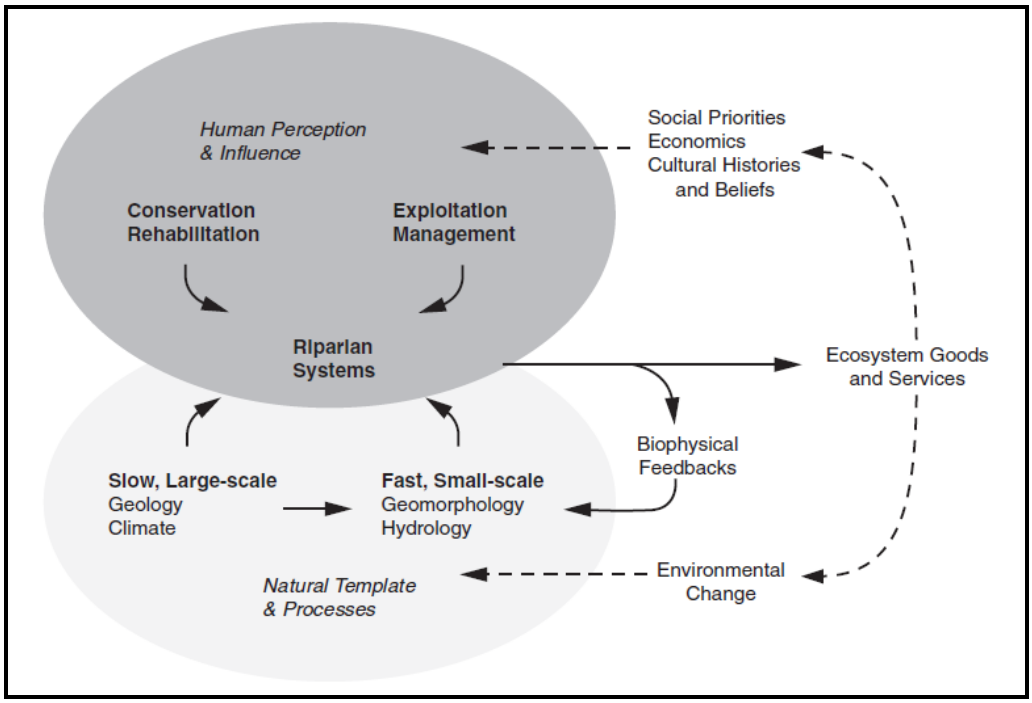

Figure 2 A diagram showing the different factors affecting the riparian systems and their interconnectedness (Naiman et al., 2005).

Riparian ecosystems are affected by natural factors such as geology, climate, hydrology and natural processes (Figure 2). These in turn can be influenced by environmental changes as well as biophysical feedbacks. Humans also play a part in influencing the riparian systems. Human influence can be in terms of conservation or exploitation and these in turn are influenced by social, economical and cultural factors. Humans can directly influence the natural factors by altering the natural cycle. Ultimately, the ecosystem goods and services influence all of natural and human factors (Naiman et al., 2005).

LAND USE CHANGE AND ITS IMPACT ON RIPARIAN SYSTEMS

Riparian ecosystems such as those of streams and rivers are largely influenced by land uses in the catchments which they flow through (Allan, 2004; Townsend, Dolédec, Norris, Peacock, & Arbuckle, 2003). There is a wide range of literature on the effects of human-induced activities in land on the integrity of riparian systems (Allan, 2004). It is well known that land

use activities in catchments have been on the increase. Allan (2004) comments agriculture occupies most of the land in developed catchments while urban land use occupies a smaller part. In New Zealand, it is estimated only 50 % of the land cover is in native forest, native vegetation and other native land cover (Ministry for the Environment, 2007). Forests covered 80% of the land before pastoral development. However, in recent times, agricultural land use dominates most of the catchments (Quinn, 2000).

RIPARIAN RESTORATION

Ecological restoration refers to the process of aiding the recovery of an ecological system that has been damaged, degraded, or destroyed (Society for Ecological Restoration International Science & Policy Working Group, 2004). In general, an ecosystem is believed to be restored if the system contains adequate biotic and abiotic resources to develop and maintain its functions and services independently without external assistance (Society for Ecological Restoration International Science & Policy Working Group, 2004). Restored systems would also demonstrate resilience, that is, its ability to recover basic functions and attributes that have been degraded or damaged from stress or disturbance (Aronson, Floret, Le Floc'h, Ovalle, & Pontanier, 1993; Society for Ecological Restoration International Science & Policy Working Group, 2004). For restored riparian systems, it is also expected that they would be able to maintain their natural processes and provide linkages between terrestrial, aquatic and riparian systems (Naiman et al., 2005). Healthy riparian systems are essential to the survival of native flora and fauna. This will also increase water quality and aid in stabilising the hydrological system among other functions (Table 2). Therefore, there is a great need to maintain and sustain these ecosystems.

Table 2 Summary of riparian zone functions that potentially buffer streams from various land use effects (Collier et al., 1995a).

Riparian zone function	Potential in-stream effects
• Buffer banks from erosion • Buffers channels from localised changes in morphology • Buffers input of nutrients, soil, microbes and pesticides in overland flow • Denitrifies groundwater • Buffers energy inputs • Provides in-stream food supplies and habitat • Buffers flood-flows • Maintains microclimate • Provides habitat for terrestrial species • Maintains dispersal corridors	• Reduced fine sediment levels • Maintains water clarity • Reduces contaminant loads • Prevents nuisance plant growths • Encourages growth of bryophytes and thin periphyton films • Maintains lower summer maximum temperatures • Increases in-stream habitat features and terrestrial carbon inputs • Maintains food webs • Reduces floodflow effects • Increases biodiversity

2.3 INTRODUCTION TO THE TE WAIHORA/LAKE ELLESMERE

Te Waihora/Lake Ellesmere is a large, shallow, brackish coastal lake situated in South Island, New Zealand (Glennie & Taylor, 1996a). It is New Zealand's fifth largest lake and covers an area of 20,000 ha (Te Rūnanga o Ngāi Tahu & Department of Conservation, 2005). The lake was recognised as an internationally significant wetland in 1981 by the International Union for the Conservation of Nature (Glennie & Taylor, 1996a). It is a natural habitat to a diversity of plants and animals, including home to around 166 bird species among which are native and migratory birds (Te Rūnanga o Ngāi Tahu & Department of Conservation, 2005). The lake is also an important resource historically, culturally, recreationally and commercially to the people of this land.

Te Waihora/Lake Ellesmere holds a special spiritual and physical significance to the Tāngata Whenua of the land, the Ngāi Tahu. The Ngāi Tahu also calls the lake, Te Kete Ika a Rākaihautū, which means the fish basket of Rākaihautū (Canterbury Regional Council, 1996). This name refers to the abundant food source of the lake as well as its abundance of other natural materials. Some of these are significant to the Maori and include flounders, eels, yellow-eyed mullet, white bait, flax and paru. Ngāi Tahu also considers the lake as one of their most precious taonga (Canterbury Regional Council, 1996).

The lake is also popular with the recreational and commercial users. The lake is often used by bird watchers, bird hunters, fishers and for water-based recreational activities such as yachting (Canterbury Regional Council, 1996). Trout fishing is the most popular type of recreational activity while the eel fishery is the most important commercial fishery in the lake.

THE LAKE ELLESMERE CATCHMENT

The lake catchment area is about 276,000 ha (Te Rūnanga o Ngāi Tahu & Department of Conservation, 2005). There are four distinct areas of the catchment which are the foothills of the Southern Alps, the Central Canterbury Plains, the western hills of the Banks Peninsula and the lake and its margin (Canterbury Regional Council, 1996). About 79 percent of the catchment land area lies in the Canterbury plains and the rest lies in the hills and high country (Mason, Larsen, & Weeber, 1996). There is a National Water Conservation Order in place for Lake Ellesmere since 1990 which allows for granting consent to open and close the lake artificially. This in order to manage levels of the lake and hence protect the surrounding land from flooding (Glennie & Taylor, 1996a).

The lake receives inflows from surface run-off, groundwater fed-tributaries, seawater intrusions and artesian springs (Canterbury Regional Council, 1996; Te Rūnanga o Ngāi Tahu & Department of Conservation, 2005). However, it has been found that the groundwater system is the main source for nearly all of the water entering the lake, except in persistent wet periods (Figure 3) (Williams, 2008). This groundwater is recharged from rainfall, seepages from Rakaia and Waimakariri Rivers, water from irrigated races and return water from irrigated land (Williams, 2008).

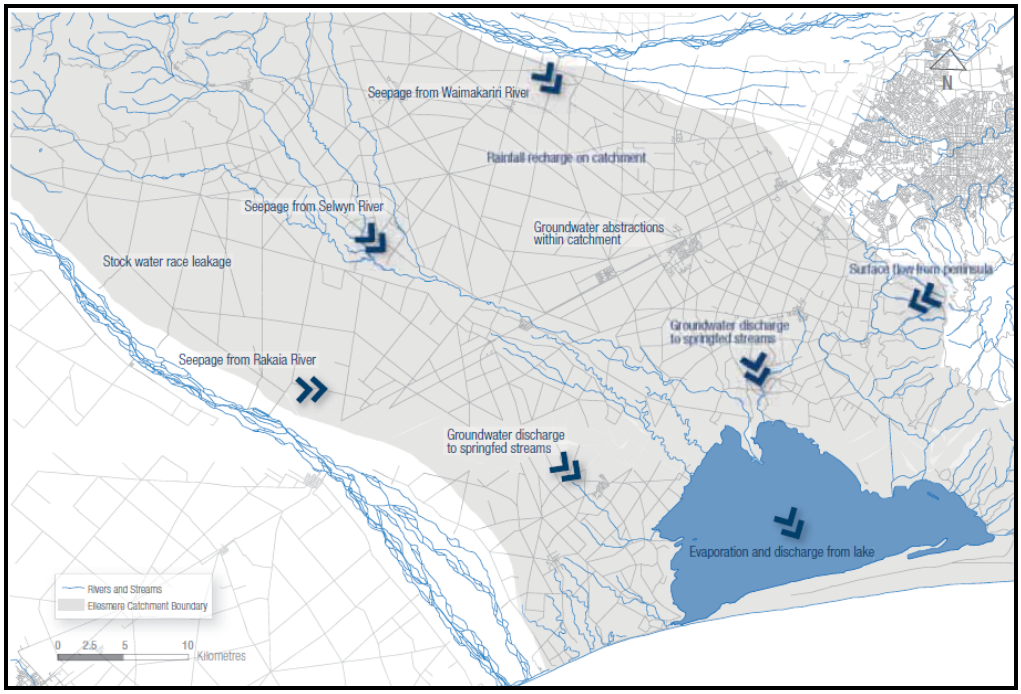

Figure 3 - Schematic water inputs and outputs in the Ellesmere catchment (Williams, 2008).

Several rivers and around 40 streams and drains flow into and recharge the lake (Figure 4) (Te Rūnanga o Ngāi Tahu & Department of Conservation, 2005). Some of the major water ways discharging into the lake include the Selwyn River, Irwell River, Halswell River, Kaituna River and Harts Creek (Te Rūnanga o Ngāi Tahu & Department of Conservation, 2005). Among these water ways, the Selwyn River and its tributaries is the most significant water way discharging into the lake. The Selwyn River flows 60km across the Plains from the foothills to Lake Ellesmere (Kelly, Davey, & James 2006). However, not all parts of the river flow all year around. The middle part is observed to have no surface-flow for several months of the year (Kelly et al., 2006). It is also observed that when the river bed reaches the Plains, the water is lost to the groundwater system and the river remains dry for next 35 km except where it appears as springs at the confluence of Hororata River (Kelly et al., 2006; Williams, 2008). The water of the Selwyn River appears as a river 15km upstream from the Lake

Ellesmere. All these waterways discharging into the lake are subject to land use impacts as they flow through intensively farmed land (Hayward & Ward, 2008).

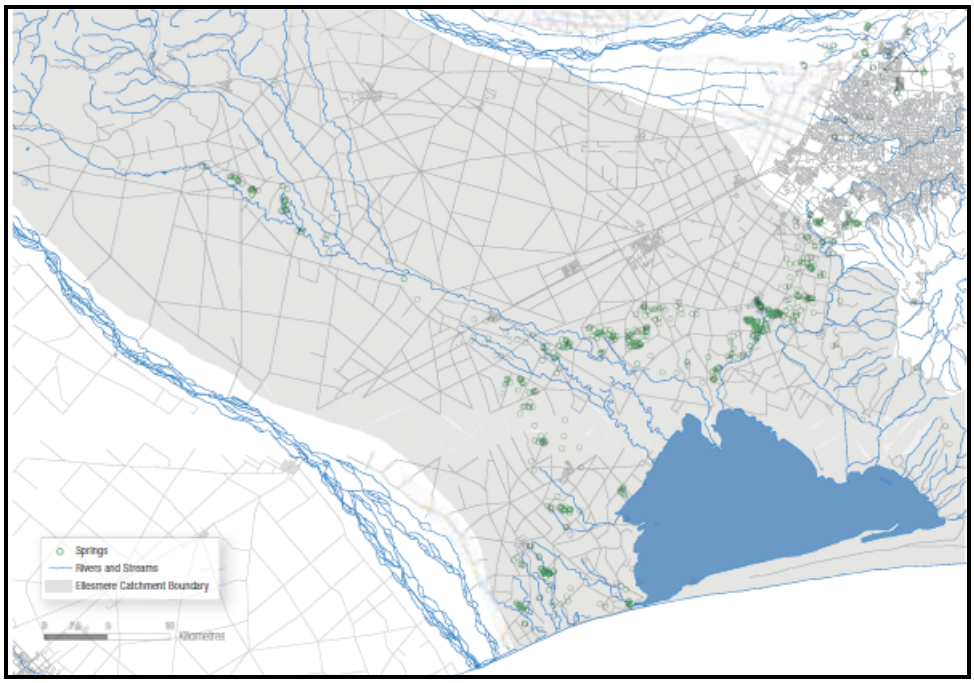

Figure 4- Distribution of springs and major rivers recharging the lake (Williams, 2008).

The lake catchment has been largely modified since the arrival of humans in this area. About 20% of the land is considered as highly productive and at least 80% of the land is in pasture (Canterbury Regional Council, 1996; Glennie & Taylor, 1996b). A significant amount of drainage and flood protection was done in the past and this has further modified the land from its already altered state. Much of the flax and raupo wetlands were transformed into fertile farms (Canterbury Regional Council, 1996). Agriculture is the dominant land use of the catchment and includes cropping, life stock and dairying (Environment Canterbury, 2009). It is recognised that the lake mainly receives nutrients from runoff and animal effluent (Environment Canterbury, 2009).The catchment areas have also seen a boom in population since settlement. The close vicinity to Christchurch City has also added the pressure with increases in lifestyle blocks and other peri-urban developments. There is also residential and some industrial land use areas near the western fringe of the city (Environment Canterbury, 2009).

There is growing concern for environmental issues with the increase in population and intensive farming in the catchment. The demand for water is growing and hence puts an intense pressure on surface and groundwater quality as well as quantity. There is also concern about the nutrient inputs from animal effluents and run-off. Therefore, there is currently a

growing attention to the impacts on water quality, quantity and biodiversity of the ecosystem as a result of these land use changes.

2.4 RIPARIAN RESTORATION IN THE TE WAIHORA/ LAKE ELLESMERE CATCHMENT

Waihora Ellesmere Trust (WET) is one of the groups working to restore the ecological health of the lake and its catchment. WET is a community charitable trust formed in 2004. The Trust was formed after two years of extensive consultation by the Lake Issues Group that was formed to address the concerns about the decline in water quality. WET has over 100 members from diverse areas including local residents, farmers, fishermen, bird-watchers and iwi (Waihora Ellesmere Trust, 2009c). WET is working on three fronts to achieve its vision and the objectives are to (Waihora Ellesmere Trust, 2009b):

- restoring the ecosystem through riparian and wetland enhancement,
- promoting understanding and awareness of the lake through field days, newsletters and programmes, and
- promoting and supporting best management practices in order to maintain and enhance the ecological health of the lake and its tributaries.

In order to achieve these objectives, WET has been working on restoring the ecosystem through riparian restoration along the lake's many tributaries. Over the last seven years, riparian restoration planting has been done at over 20 sites around the lake catchment. This involved the planting of native plants in the riparian margins of creeks, streams and rivers. There have been over 50,000 plants planted in the last two planting seasons. Plantings have been done on both public and private lands. The purpose of the planting projects differed and ranges from awareness raising, biodiversity enhancement, erosion reduction, aesthetic reasons and enhancing water quality. The circumstances leading to each planting also differs and hence each riparian restoration project has a life history of its own.

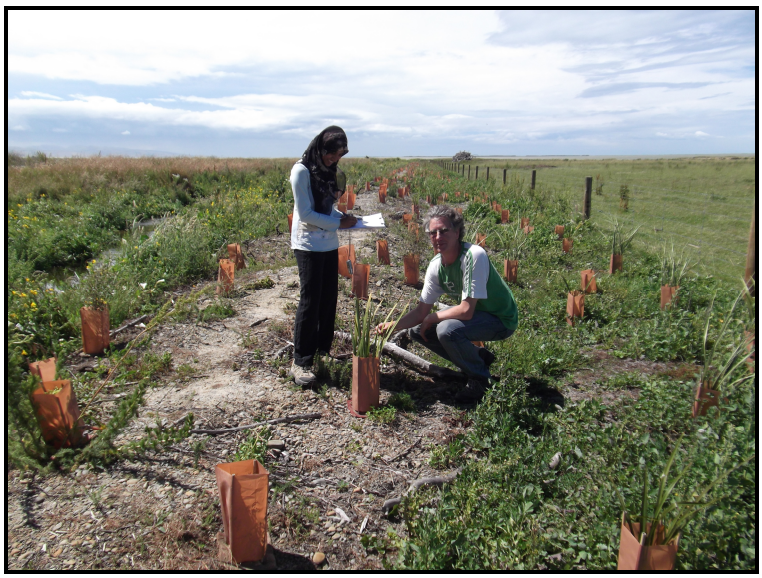

Figure 5 Student and lecturer observing native plantings at Boggy Creek site (Photo: A. Lomax, WET Manager)

WET conducts riparian restoration work through funding from different sources. WET started seeking funds to implement an extensive riparian restoration work in the catchment after the findings of the Living Lake Symposium. In 2008, WET received major funding which facilitated them to initiate the Waihora Ellesmere catchment riparian restoration programme. Since then, WET has received funding from other sources to continue their work (Table 3). The restoration programme has identified several sub-catchments as priority areas for riparian restoration. These include Hororata, LI/LII/Liffey, Waikekewai, Kaituna, Johnsons Rd, Waianiwaniwa, Silverstream, and Leeston. (Waihora Ellesmere Trust, 2009a). WET intends to focus their attention on these catchments while continuing their work in other sub-catchments such as the Halswell catchment.

Table 3 WET Funding sources (WET project documents)

MAIN FUNDING SOURCES FOR WET's RIPARIAN RESTORATION
• SMF Sustainable Management Fund • SFF Sustainable Farming Fund • CCF Community Conservation Fund • EEF Environmental Enhancement Fund • HTF Honda Tree Fund • In kind contributions from Environment Canterbury (ECan), Selwyn District Council (SDC), Department of Conservation (DOC), Fish and Game, Ngāi Tahu • In kind contributions from WET Trustee, Lincoln University Staff and students, partners such as Youth Hostel Association (YHA) • In kind contributions from farmers to conduct work such as fencing

3 LITERATURE REVIEW

This chapter initially describes a literature review of riparian restoration and diffusion of innovations theory. This follows a review of the literature discussing concepts of diffusion theory in the spread of conservation in agricultural domains.

3.1 RIPARIAN RESTORATION

3.1.1 Need for riparian restoration

Many of the riparian systems around the world are in need of recovery or restoration. Over the past decades, human activities have significantly modified and transformed riparian systems (Naiman et al., 2005). The increase in human population, changes in resource use, technological improvements and changes in social systems have been identified as some of the key drivers of human disturbances that impact ecosystems (Naiman et al., 2005).

There is a history of human interference in ecosystems, especially land use change, which has altered the native landscape to other forms such as pastoral and urban land covers (Landers, 1997). Riparian systems were exploited and used as they were perceived as fertile lands for agriculture (Naiman et al., 2005). People are becoming more aware now that riparian systems are an integral part of the catchment. It is being recognised that a riparian system holds ecological, social, economical and cultural benefits for the community (Table 1 and 2). Therefore, there is a drive to develop management strategies that aid to maintain the integrity and restoration of our streams, rivers and other riparian ecosystems.

Conservation, rehabilitation, reallocation and restoration are similar processes that deal with the natural processes and integrity of an ecosystem (Aronson et al., 1993; Naiman et al., 2005). Restoration is just one of the responses that aim to deal with restoring the functionality of an ecosystem (Aronson et al., 1993). Figure 6 demonstrates a model of ecosystem degradation and the likely management responses. The original state of the ecosystem is vague but it is understood that with the increase in disturbances the ecosystems will get damaged and degraded. There are a number of possible interventions such as rehabilitation, restoration and reallocation.

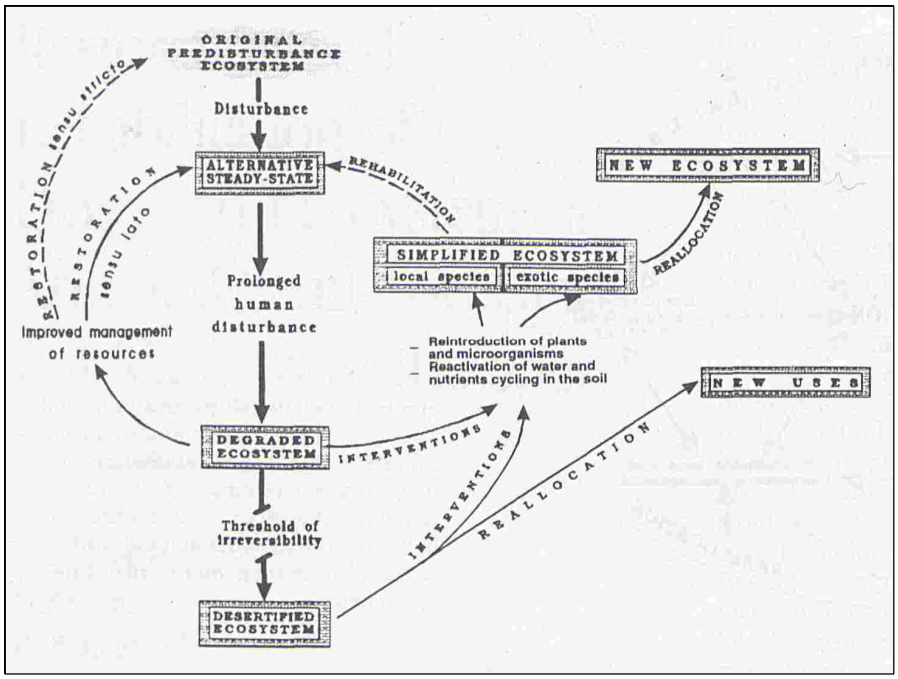

Figure 6 Diagram of ecosystem degradation and some of the likely responses (Aronson et al., 1993, p10).

Riparian restoration is an aspect of a management strategy that attempts to re-establish an ecosystem to its former state, then monitors this development and evaluates whether this ecosystem can function independently without external aid (Society for Ecological Restoration International Science & Policy Working Group, 2004). Some of the common management activities that are in place to aid in restoring riparian systems include replanting of native plants, fencing to remove livestock from entering stream corridors, channel engineering and removal of dams (Bernhardt et al., 2007).

Clewell and Aronson (2006) suggest a typology of rationales which places the reasons as to why ecosystems are restored. One such rationale is the technocratic rationale that refers to the work conducted by government agencies and other institutions to achieve a specific goal such as restore social values of the ecosystem. Another rationale includes the biotic rationale where restoration is conducted purely to recover features of lost biodiversity. The idealistic rationale refers to situations where individuals undertake restoration because of personal or cultural concerns for the environment and the land (Clewell & Aronson, 2006). Idealistic restoration projects may use public funding but the work is generally conducted by local stakeholders, often volunteers. Alternatively, there can also be a pragmatic rationale for doing restoration work. For example, this may be to restore natural capital or work towards decreasing global warming.

Ecological restoration initiatives are on the rise as people become more aware of the issues threatening riparian systems. For example, in the United States it is estimated that activities to restore rivers is rising exponentially and a lot of resources are being added in to aid these processes (Bernhardt et al., 2007). Similarly, restoration attempts are taking place elsewhere in the world such as those in New Zealand.

3.1.2 Riparian restoration in New Zealand

New Zealand's biodiversity consists of unique ecosystems such as braided river ecosystems and many endemic species (New Zealand Biodiversity, 2000). Aquatic habitats account for 3% of land area of which includes 776 lakes (Collier, 1994). Collier (1994) estimates that mainland New Zealand contains 4 million kilometres of streams and channels. New Zealand's biodiversity is important environmentally as well as culturally. The indigenous people of the land, Maori, have a cultural link to many of the native species and ecosystems (Ministry for the Environment, 2007).

Unfortunately, as a result of human settlement a high percentage of these native flora and fauna have been lost or damaged (Davis & Meurk, 2001). Around two thirds of forests prior to human settlement have been lost and 90% of the wetlands have been drained (Collier, 1994; Davis & Meurk, 2001) (Figure 7). Landscapes have been largely modified and cleared for agriculture, timber and other land use (McFadgen & Simpson, 1996). In the North Island, it is estimated that half the length of rivers now flow through catchments with transformed vegetation cover (Collier, 1994).

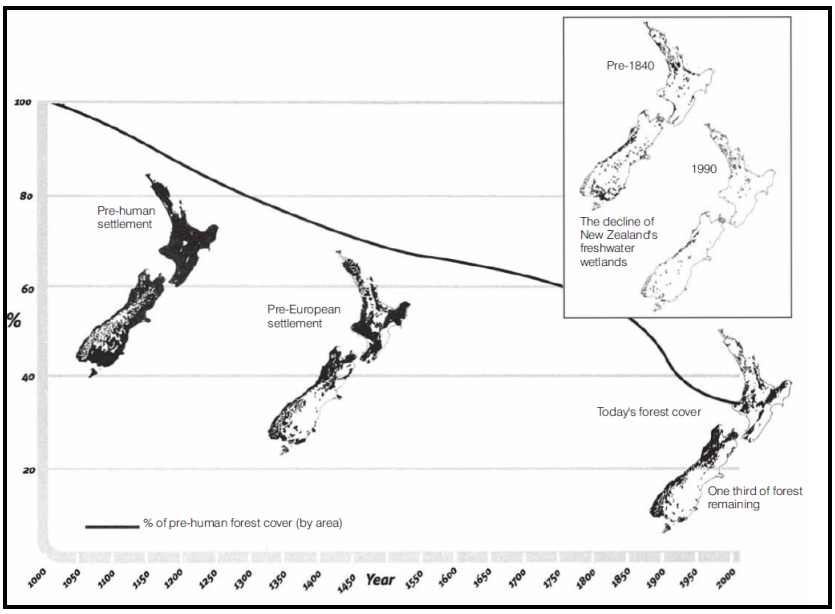

Figure 7 The decline of New Zealand's forests and wetlands (Davis & Meurk, 2001).

The greatest modifications to riparian systems of New Zealand have occurred in agricultural and urban landscapes. As a result, there has been significant degradation of New Zealand's riparian ecosystems (Marden, Rowan, & Phillips, 2005). Issues threatening these systems include sedimentation, decrease in native flora and fauna, decrease in water quality and quantity, increase in exotic species such as willows and loss of in-stream habitat.

Attempts to regenerate the health of water bodies started to increase as people became more aware of the degradation of the waterways and the decrease in native flora and fauna (Marden et al., 2005). Initially there was concern about the impact of agriculture on water quality and quantity as well as trout fisheries. As a response, people started creating riparian retirement areas between 1975 and 1982 (Quinn, Williamson, Smith, & Vickers, 1992). Riparian retirement involves fencing off a strip 20 m or wider along a water way (Quinn et al., 1992).

By the twentieth century, people were interested in being actively involved in restoring riparian systems by replanting native plants and establishing restoration programmes (Marden et al., 2005). There is now public pressure as well as government pressure to enhance the indigenous vegetation of New Zealand. The Resource Management Act 1991 (RMA) places a great importance on "safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and avoiding, remedying, or mitigating any adverse effects of activities on the environment" (Marden et al., 2005). In addition, in RMA 1991 it is also stated in the matters of national importance that all persons exercising functions under the act shall recognise and provide for "the preservation of the natural character … wetlands, and lakes and rivers and their margins, and the protection of them from inappropriate subdivision, use, and development".

In New Zealand, there has been restoration work done in waterways over the years. It may be that a government agency is undertaking restoration as a way to recover social values or it may be that restoration is undertaken for awareness purposes (Clewell & Aronson, 2006). But whatever the purpose is, riparian restoration is undertaken in the aim of recovering the ecosystem to a desirable state. In Canterbury, New Zealand, a number of riparian restoration initiatives are in place. Over the years, individuals, community groups, government agencies and local authorities have been involved in a number of restoration projects. For example, the Living Stream Programme conducted by Environment Canterbury aim to maintain the health of rural water ways through improving practices that impact them (Environment Canterbury, 2010).

3.2 DIFFUSION OF INNOVATIONS THEORY

3.2.1 History of diffusion theory research

Diffusion of innovations theory attempts to explain how innovations spread through a population (Atwell, Schulte, & Westphal, 2009). This theory, which emerged in the early 20th century, has been shaped and used in studies from various disciplines. The historical roots of diffusion theory lies in the work of some sociologists and anthropologists of early 1900s (Rogers, 2003). These researchers (e.g. Tarde 1903) were interested in knowing how customs, attitudes, practices and ideas spread (Coleman, Katz, & Menzel, 1957).

The foundation for diffusion studies was laid down by Gabriel Tarde's in his book 'The laws of limitation' in 1903 (Katz, 1999; Wejnert, 2002). Tarde used different terms such as imitation instead of adoption but his research issues are common to those in current diffusion studies (Rogers, 2003). Tarde (1903, as cited in Rogers 2003) defined diffusion of innovations as a basic element to explain social change and described imitation (or adoption as in other studies) as one of the social acts. It was not until four decades later that Ryan and Gross's (1943) investigation of the spread of hybrid seed-corn use among farmers in Iowa, USA sparked renewed interest in Tarde's concepts of diffusion (Rogers, 2003; Wejnert, 2002). The research questions posed by Ryan and Gross (1943) have continued to be part of most later diffusion studies and thus the hybrid seed-corn study has become an academic template followed by most diffusion researchers (Rogers, 2003).

The subsequent rise in diffusion studies was initiated in the field of rural sociology but other disciplinary fields such as anthropology, education, public health, geography, political science and marketing were quick to follow. Applications in diffusion theory have been broadened over the years to include a range of innovations (Rogers, 2003). In recent times, world events, the internet, health epidemics and other factors are stimulating interest in diffusion studies (Rogers, 2003).

3.2.2 Elements of diffusion of innovations

Diffusion refers to the spread of a diffusing item (e.g. a practice or an idea) in a social system. The spread describes the movement from a source to an adopter through various pathways (Strang & Soule, 1998). Rogers (2003) describes diffusion as a special type of communication

in which the diffused messages are considered as new ideas. It is also likened to social change because an innovation can prompt changes in a social system during the process of diffusion (Kanekar, 2008; Rogers, 2003). Rogers (2003) provides a conceptual diagram of the diffusion model (Figure 8). It consists of many variables contributing to the whole process. These variables are explained in more detail in the following paragraphs.

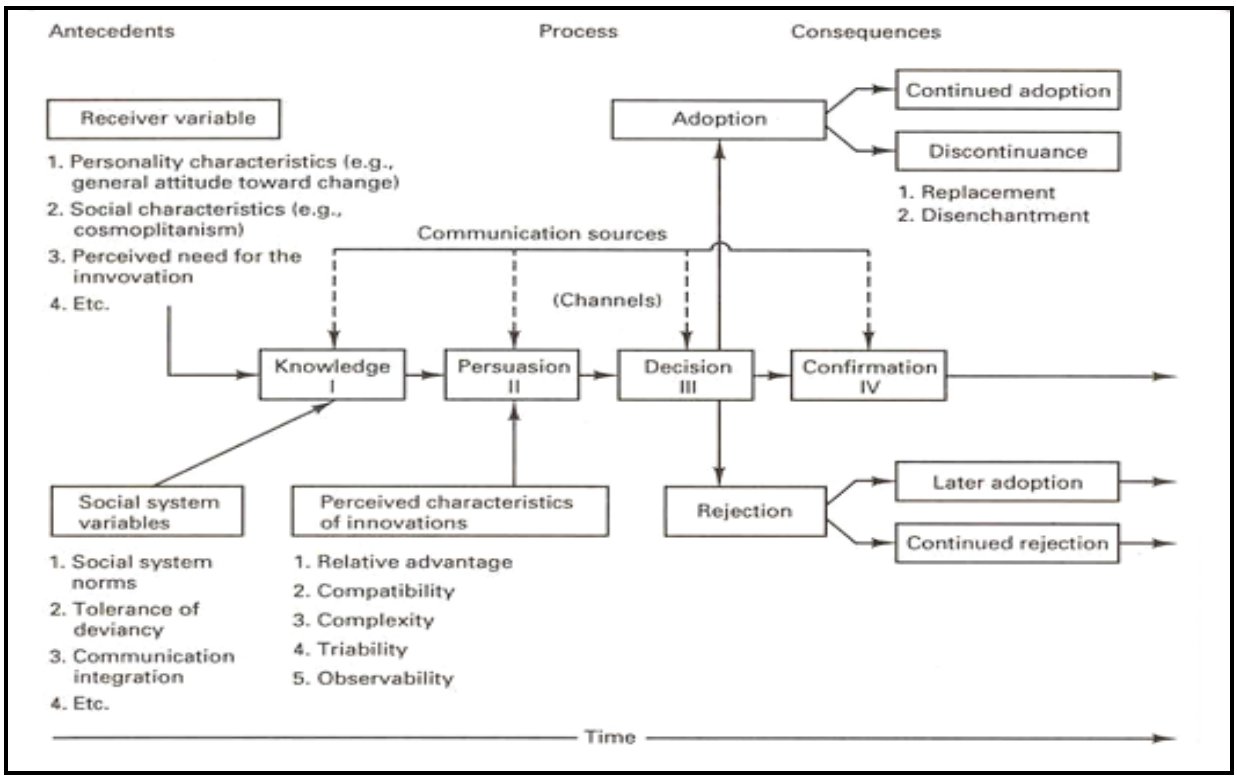

Figure 8 Overview of the Diffusion innovation model (modified from Rogers, 2003, p.170).

Rogers (2003) has authoritatively reviewed the diffusion of innovation theory (Strang & Soule, 1998). His diffusion typology is the most commonly used one in diffusion research (Katz, 1999). He identifies the innovation, communication channels, time and social system as the four main elements evident in most diffusion studies whether planned or spontaneous (Rogers, 2003, pp.11-35). The characteristics of these elements play an integral role in the diffusion process. Furthermore, Wejnert (2002) identifies three major categories comprised of variables which influence the diffusion process. The categories are the characteristics of innovation, characteristics of innovators and environmental context (Wejnert, 2002). The following paragraphs explain the four elements as described by Rogers (2003). However, as these elements contain many of the variables stated by Wejnert (2002) these are discussed in the relevant sections.

I THE INNOVATION

One of the main questions concerning an innovation is the question of why some innovations spread more quickly than others and why some are adopted more easily than others. The differences in rates of adoption can be explained by the characteristics of innovations as perceived by individuals (Rogers, 2003). Uncertainty and risk add into these characteristics (Strang & Soule, 1998).

Wejnert (2002) identifies those characteristics of the innovation that influence the diffusion process. One such characteristic is the public consequence of the innovation and private consequences of innovation. Innovation with public consequences usually includes impacts on the wider society such as countries, state or social movements (Wejnert, 2002). Consequences could be in the form of changes to regulation and law. This differs from innovations with private consequences where the innovation is generally introduced to improve the quality of lifestyle of individuals (Wejnert, 2002). Usually, the consequence of adoption is felt by individual, small groups of individuals, peer groups or rural communities. The diffusion of innovations with private consequence is to a great extent influenced by pressure of social networks and spatial effects such as geographical proximity and interpersonal communication (Wejnert, 2002).

Rogers (2003) explains that those innovations which have a greater relative advantage, are compatible, trialable, observable and less complex will be adopted at a faster rate. These are explained below.

a) Relative advantage

This is the degree to which an innovation is perceived as being advantageous or beneficial to the individual. The key aspect of note is that it does not matter whether the innovation itself has its advantages, but whether the individual sees the innovation as being an advantage.

b) Compatibility

This is the degree to which an innovation is perceived as being uniform with current practices, values, experiences and needs of an individual (Rogers, 2003). The rate of adoption would be quicker if the innovation is consistent with the norms and values of the potential adopter and the adopter's current lifestyle. It also aids if the innovation is consistent with the norms and value of the social system in which it diffuses through.

Wejnert (2002) identifies cost as a potential inhibitor of adoption. A cost becomes a barrier to adoption when it exceeds the resource capacity of the potential adopter. Costs can be direct or indirect and not necessarily always in monetary form. For example, indirect costs can be in the form of a social cost such as the stigmatisation of individuals who adopt innovations that is socially unacceptable (Wejnert, 2002).

Adoption is also impacted by the geographical condition of the location where the innovation is diffused. It appears that an innovation must be compatible with the ecological conditions such as climate, weather or soil. For example, one study found that farmers in India did not adopt a certain variety of cereal as the location it was introduced to had high rainfall and the cereal variety had little resistance to excess water (Jansen, Walker, & Barker, 1990).

c) Complexity

This is the degree to which an innovation is perceived as being complex and difficult to understand (Rogers, 2003). An innovation that is simple and easy to grasp by individuals would take less time to be adopted than those which are more complex.

d) Trialability

This is the degree to which an innovation can be tested or trialled at a small scale (Rogers, 2003). The trialability of an innovation will aid the individual in making the adoption decision. It will also decrease uncertainty as a potential adopters get to test the innovation themselves.

Diffusion studies have also shown that a familiarity with an innovation would reduce the uncertainty and risk associated with it (Wejnert, 2002). For example, a farmer who had trialled on hybrid-seeds is more likely to adopt a different variety of hybrid seed.

e) Observability

This is the degree to which an innovation can be demonstrated to others (Rogers, 2003). The rate of adoption will be quicker if an innovation is visible to individuals. This characteristic works better in innovations which can be visibly seen to others than those which cannot be.

II COMMUNICATION CHANNELS

Communication is a process in which information is shared and exchanged between individuals (Rogers, 2003). The communication process usually involves an innovation, an individual or group that has knowledge of the innovation and/or an individual or group that has no current knowledge of the innovation and the communication channels.

In recent times, mass media is the most effective way of spreading information on an innovation. Mass media involves the use of a mass medium such as television, newspapers, radio or internet (Strang & Soule, 1998). However, interpersonal communication through interpersonal channels is still influential in the diffusion of an innovation (Atwell et al., 2009). It is seen to be most effective in diffusion of an innovation in rural communities (Atwell et al., 2009). Interpersonal channels are those which involve a face-to-face communication between individuals (Rogers, 2003). This includes a subjective evaluation from individuals who have knowledge of the innovation passed on to an individual not aware of the innovation. In addition, studies have found that demonstration sites and field visits have been effective resources in educating and diffusing information about agricultural resources (Tumbo, Mutabazi, Byakugila, & Mahoo, 2010).

Torstern Hagerstrand's (1952-1953, 1965, 1967) research in cultural diffusion and migration emphasised the influence of the communication process on adoption of an innovation (Brown, 1981). He developed a conceptual model to explain the diffusion and adoption of an innovation through space and time (Rogers, 2003). Factors influencing communication needs to be studied for better understanding of diffusion (Brown, 2009). Hägerstrand's work indicated that the diffusion of information must be spatially constrained and the further a farmer is away from an early adopter there is less likelihood of adopting the practice (Webber, Lutz, & Brown, 2006). In addition, it was noted that personal contacts were important for diffusing information and the adoption process. Other researchers have also expressed that geographical proximity can impact the communication process and therefore affect the personal interaction between individuals (Wejnert, 2002).

Furthermore, diffusion of information has been observed to occur more frequently between individuals with similar attributes such as socioeconomic status, education, beliefs and values (Rogers, 2003). Sociologists term the tendency for individuals to interact with those who have similar attributes as *homophily* and the tendency for individuals to interact with those who have different attributes as *heterophily* (Feder & Savastano, 2006; Rogers, 2003). It has been perceived that communication is more effective and there is greater sharing of information if individuals are similar or homophilous (Burt, 1999; Rogers, 2003). Similarly, Valente and Davis (1999) suggested that learning is more efficient if it is provided through their close peers. This statement was stated in reference to planned diffusion programmes where individuals are selected to accelerate the diffusion process. However, Rogers (2003) suggests that a degree of heterophily is also essential for exchange of new knowledge. He explains that

if individuals are identical with regard to their educational background it is hard to exchange any new information.

III TIME

Time dimension is an important factor of diffusion studies. There are three different ways in which the time dimension is involved in diffusion. These are:

a) The innovation-decision process

This is the process through which an individual acquires first knowledge of an innovation, to discovering about the innovation, to accept or reject the innovation and eventually takes an action on it (Rogers, 2003). These are represented in five stages, knowledge; persuasion, decision, implementation and confirmation (Figure 8). Confirmation is the last stage where the individual reconfirms the decision already made. The last two stages are interrelated and are not always independent stages. The last stage is important in situations where an individual rethinks the decision to adopt or reject and reverses this decision. Innovation-decision can be made individually or collectively by an adopting unit (e.g. groups of individuals) or by an authority (e.g. an organisation).

b) Innovativeness and adopter categories

Innovativeness is described as the degree to which an individual adopts an innovation relatively earlier than other individuals (Rogers, 2003). Innovativeness depends on variables such as socio-economic status, personality values and community behaviour. Innovativeness is described in the following adopter categories, innovators, early adopters, early majority, late majority and the laggards (Figure 9). Generally, members of a social system can be observed to be belonging to one of them.

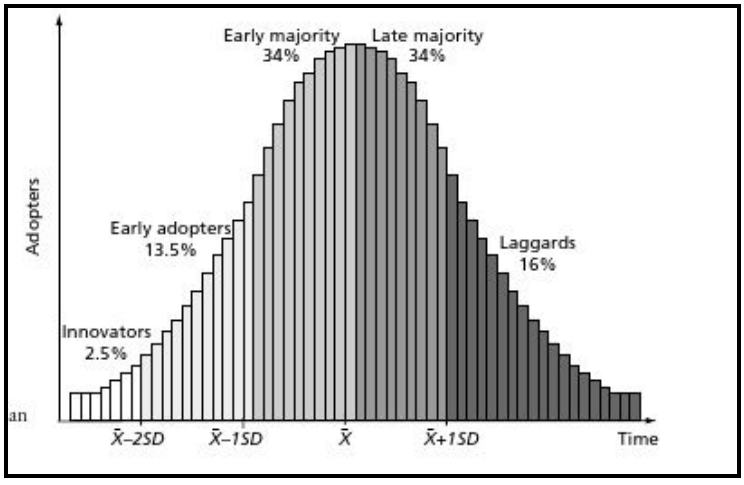

Figure 9 Classification of adopters with regard to innovativeness and time (Greenhalgh et.al., 2008, p.101).

However, this categorisation does not mean that members of the society will apply the same adoption decision to each innovation they come across (Pannell et al., 2006). For example, an early adopter of one innovation can be one of the late majorities or even a laggard for another innovation. To a great extent, characteristics of an innovation influences the innovativeness (Pannell et al., 2006).

c) Rate of adoption

The rate of adoption is defined as the rate at which an innovation is readily adopted by members of a social system (Rogers, 2003). An s-shaped curve describes how the rate of adoption occurs (Figure 9). The innovators are the first to adopt and with more individuals adopting the curve goes up. Eventually only a small group of individuals remain who are referred as laggards. The diffusion process is complete after this group become adopters. There are various factors perceived as influencing the rate of adoption such as attributes of innovation, innovation decision, communication, social system and role of change agents (Figure 10).

IV SOCIAL SYSTEM

Rogers (2003) describes a social system as interrelated units forming a system that works together to explore ways to accomplish a common goal. Members of the social system may be an individual, groups, organisations or smaller systems. Understanding the norms and characteristics of a social system is crucial for a diffusion study in that system. One diffusion researcher, Katz (1961) commented that if social systems are not included in diffusion studies then it would be like studying blood circulation without understanding the roles of veins and arteries (as cited in Rogers, 2003). Information sharing and knowledge has been perceived as being embedded in the web of social of interactions between individuals (Feder & Savastano, 2006). Feder (2006) suggests that the pattern of information flows between individuals is connected to the social network, their contacts in the network as well as their status in that network. Studies have identified three types of connectedness important for the social network (Pretty & Smith, 2004). Bonding refers to the links between individuals of local groups, usually with similar objectives. Bridging refers to the links between groups across communities who may have different objectives. The last one, linking refers to the vertical communication with external agencies.

Similarly, it has also been suggested an innovation spreads more quickly if the social capital in the particular community is greater (Pretty & Smith, 2004). In this statement, social capital refers to aspects in the social structure that act as resources for individuals (Pretty & Smith, 2004). For example, it refers to the trust between members of the society and relationships of reciprocity. Pretty and Smith (2004) suggests social capital can facilitate cooperation and as a result individuals are more keen to invest in collective activities. For example, in communities high in social capital a practice could be adopted easier if an individual finds out another member is doing the same action. There is a sense of trust built in the community that enables individuals to participate in action deemed desirable by the whole society.

The nature of the system is observed to be influencing the rate of adoption along with other variables (Figure 10).

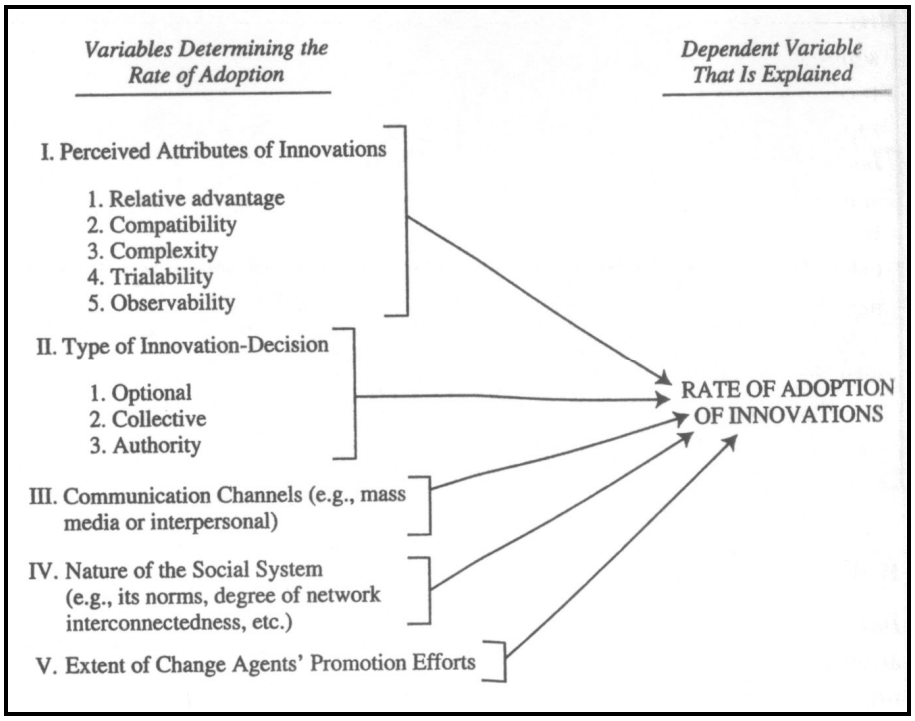

Figure 10 Variables influencing the rate of adoption (Rogers, 2003, p.222).

There are certain individuals operating in the system that act as catalysts in diffusion. Opinion leaders and change agents refer to these individuals who have a great influence in the diffusion process (Rogers, 2003). Often, opinion leaders are community members central to a system and hence this may make them more influential (Lundblad, 2003; Valente & Davis, 1999). Opinion leaders could be neighbours, members from a community group or any individual well-known within the community. For example, a study done in sub-Saharan Africa discussed the role of internal groups such as family members, self-help community groups, relatives and neighbours in the diffusion and adoption of water system innovations (Tumbo et al., 2010). Change agents on the other hand are individuals external to the system

but can influence change (Lundblad, 2003). They could be agricultural extension officers, members from non-governmental agencies (NGO) and governmental agencies (Tumbo et al., 2010).

Opinion leaders can influence the views of the other members. Their influence lies in their status, expertise, competence, leaderships, links to external sources and experience (Feder & Savastano, 2006; Lundblad, 2003). They are observed to be conforming to the social norms and values and often considered as role models. These characteristics enable them to offer information and advice about an innovation to the wider community (Feder & Savastano, 2006). However, their influence in diffusion does not necessarily make them early adopters. Often, opinion leaders need to be convinced on the innovation too (Deroïan, 2002). Opinion leadership is informal rather than formal and it is not a type of a status.

Change agents are professionals usually representing change agencies and advocate views desirable to the change agency (Rogers, 2003). Generally, they differ from the society as they possess special knowledge or expertise (Lundblad, 2003). Sometimes they have been observed to be using opinion leaders to gain acceptance in the social system to make way for adoption (Lundblad, 2003). Many studies have found that change agents are effective in aiding the adoption decision. For example, a study done in Africa found that adoption of terraces (a water system innovation) increased with the intervention of NGOs in the catchment area (Tumbo et al., 2010).

3.2.3 Criticisms to the diffusion studies

Like many other theories, there are limitations of the diffusion of innovations theory. It is important to be aware of its shortcomings and biases when applying diffusion concepts to a study. Diffusion theory has been criticised mainly because it has a great focus on positive outcomes of the innovation; focus on progressive farmers, issues from lengthiness of the process and the focus on unidirectional communication.

There have been various other models developed as alternatives for the diffusion model, to investigate diffusion and behaviour of farmers (Ommania, Chizarib, Salmanzadeha, & Faraj Allah Hosaini, 2009). Ommania et.al. (2009) explores the use of four of these models and compared it to the diffusion model with regard to sustainable agricultural practices (Figure 11). The models explored were the farm structure model, multiplicity model, technology acceptance model and the Marcus model. These models contain concepts of diffusion model with some modifications. Ommania et.al. (2009) suggest that a modification of the

multiplicity model (a combination of diffusion model and farm structure model) is a better predictor of adoption behaviour of farmers than the diffusion model.

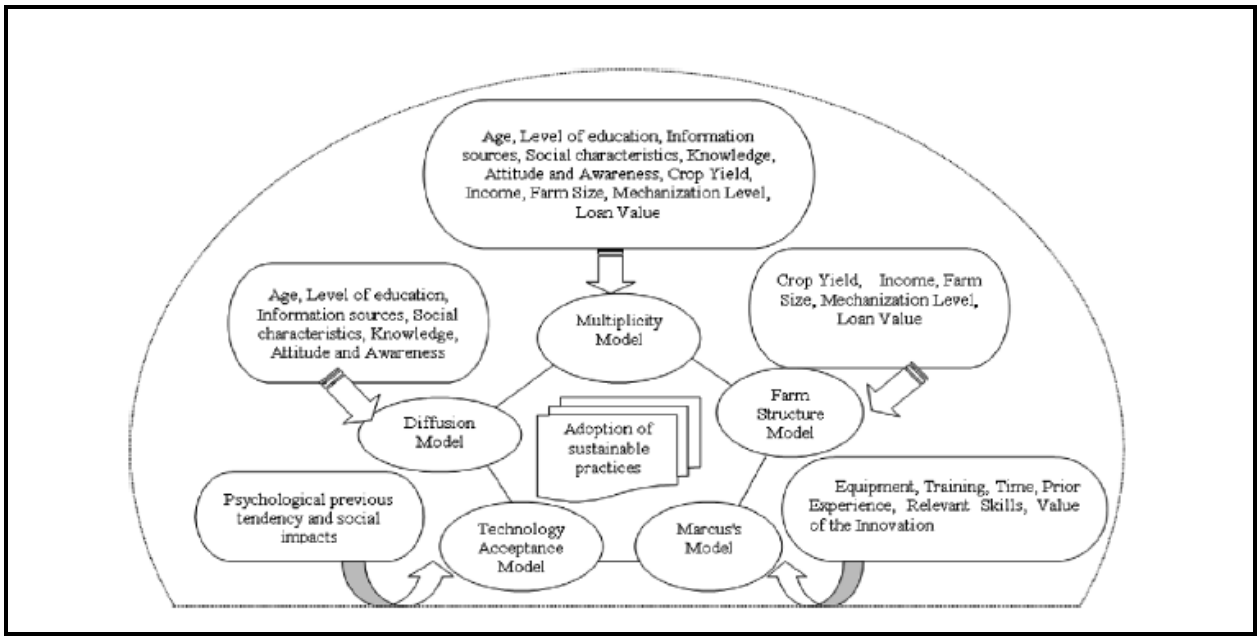

Figure 11 Models predicting farmer behaviour with regard to sustainable agriculture (Ommani et.al., 2009).

The major criticisms to the diffusion theory are presented below.

- The pro-innovation ('measuring the measurable') bias reflects the assumptions that all innovations would be diffused rapidly and adopted by all members of a society (Rogers, 2003). In addition, rejection of an innovation is not considered. There is a strong bias towards the innovation itself and it is thought that the diffusion process would result in positive outcomes. Less attention has been given to the undesirable consequences of innovations. Often, the assumption is that all innovations are deemed good (Sveiby, Gripenberg, Segercrantz, Eriksson, & Aminoff, 2009). Therefore, this ignores the fact that an innovation may not be perceived as good by potential adopters or may lead to undesired consequences. There is also tendency to blame the individuals rather than the innovation (McMaster & Wastell, 2005). For example, often an individual's resistance to a product is given greater importance than issues with an innovation. Currently, there is more literature available about innovations with positives outcomes and those which had spread rapidly as a consequence of this type of bias (Greenhalgh, Robert, & Bate, 2005). There is a strong selection bias for the innovation to be researched where popular practices gets selected quickly (Strang &

Soule, 1998). This bias has also led researchers to ignore diffusion studies on anti-diffusion programs such as those which attempt to stop the spreading of bad innovations, for example, cocaine (Rogers, 2003).

- The recall problem is a particular issue that arises in diffusion research related to time of adoption. It occurs when adopters are asked to recall about their past innovation experiences and asked to recall the time of decision making (Rogers, 2003). Diffusion process includes the time factor, but it is not always easy to get information on this in diffusion studies. There is significant room for inaccuracies as some adopters may confuse the timing.

- The issue of equality of diffusion is especially noticed in the developing countries. Research has shown that at times diffusion of innovations has increased the socio-economic gap between the lower and upper status groups in a society (Rogers, 2003). For example, an agricultural innovation that is costly would attract eager and wealthier farmers. It is also criticised that the theory does not provide for the economical, institutional and structural environment of farming (Padel, 2001).

  Unforeseen negative consequences of an innovation can also add into the discrepancies in the socio-economic status of a society. For example, this effect is demonstrated in the case study of tomato pickers of California where the introduction of harvesting machines replaced thousands of tomato hand pickers (Rogers, 2003). The social consequence of the innovation was not considered by those who introduced it. There are also times where the adoption is not well understood by the adopters. For example, farmers in an Indian agricultural scheme adopted new fertilisers but destroyed most of their crops when they used too much of it (Anis, 2009). In addition, Melkote and Steeves (2001) argued that diffusion of early agricultural innovations at times ignored the unequal distribution of innovation to the society. For example, they state that in early diffusion studies development agencies focussed on diffusing information to keen farmers with higher socio-economic status and it was assumed that the effect would trickle down to farmers at the lower end. Diffusion theory has been criticised for focusing too much on progressive farmers (Ommania et al., 2009). It is evident from early diffusion studies in agriculture that development agencies has used this ‘progressive farmer’ strategy and focussed on diffusion knowledge to farmers with higher socio-economic status (Melkote & Steeves, 2001; Ommania et al., 2009).

- There was also criticism that in the theory, communication is generally occurring in a 'one-way message flow'. This one-way message flow has been suggested to direct the flow of information from the top-down, for example ideas from the professionals or experts to the commoner (Melkote & Steeves, 2001). Melkote and Steeves (2001) stated that this places restrictions on the flow of information and ideas from the bottom-up, for example, from the farmer to the experts. This tendency ignores the knowledge and traditional methods attained by the farmer. This one-way message flow implies that there are no innovations occurring at the receiver domain and it has been argued that this simplifies Roger's (2003) adopter classification into only innovators and adopters (McMaster & Wastell, 2005).

3.2.4 Diffusion of innovations in other disciplines

Various disciplines have been using the diffusion of innovations theory to understand the spread of an innovation in their fields. The diffusion model is conceptually relevant across many subjects and this makes its application appealing to researchers from diverse backgrounds (Rogers, 2003). Diffusion research has been conducted in a range of disciplines such as medicine, sociology, anthropology, education, marketing, geography and communication. The methodology and the analysis used in different disciplines may vary but the focus remains to get an understanding of how ideas or practices are spread (Katz, 1999; Rogers, 2003). Some examples of studies from different disciplines which have used diffusion theory are discussed below.

Rural sociology, a sub-field of sociology, appears to have produced the majority of early diffusion studies (Rogers, 2003). These researchers were interested in exploring the social networks influencing diffusion as well as observing the influence of norms and values on adoption behaviour (Greenhalgh et al., 2005). Early studies, such as the hybrid-corn study, focussed on understanding the diffusion of new agricultural products or practices that could aid in increasing farm production. Studies were conducted on innovations such as new crop varieties, farm machinery, fertilisers and weed sprays (Rogers, 2003). More recently, the focus has shifted towards sustainable agriculture with the growing concerns for environmental issues (Fliegel, 1993; Kremer et al., 2001; Rogers, 2003). For example, recent research has focussed on gaining an understanding of the adoption behaviour of farmers with regard to innovations such as conservation tillage practices and other soil and water conservation practices (Tucker & Napier, 2002).

Marketing is one of the disciplines that utilises diffusion theory abundantly. Research in this discipline has been expanding since 1960s with the rise in new technologies and usage of internet as a communication tool (Rogers, 2003). A prime focus of marketing researchers is exploring the adoption and rejection of new products (for example, mobile phones) as well as research on exploring the factors and processes affecting diffusion. Diffusion studies in marketing do not necessarily concentrate on new products. It has also been used in marketing campaigns, for example, energy conservation campaigns (Rogers, 2003).

Geography was one of the earliest disciplines that utilised concepts of diffusion theory. However, not many diffusion studies were conducted in this field. Diffusion studies in geography placed a great emphasis on the spatial aspect of the diffusion process (Clarke, 1986; Rogers, 2003). Torsten Hägerstrand was the first contributor to geographical research in diffusion and his work laid the foundation to future research in the field (Webber et al., 2006). Hägerstrand's conceptual model has been used in many studies with modifications. For example, it has been used in diffusion of irrigation wells in the Colorado plains; agricultural innovations in Mysore, India and strip cropping in south-western, Wisconsin (Brown, 2009).

3.3 DIFFUSION AND ADOPTION OF CONSERVATION IN AGRICULTURAL LANDSCAPES

The focus of this study is centred in a catchment that is largely agricultural. Therefore, it is essential to investigate the literature on diffusion of conservation practices such as ecological restoration in agricultural landscapes. In this chapter, conservation is taken as a broad term and ecological restoration is conceptualised as a component aiding conservation. There appears to be significant literature on diffusion of agricultural innovations such as new products with only limited literature on diffusion of conservation practices. However, even in these studies about conservation practices, the use of diffusion of innovations theory is not explicit, although concepts of diffusion are apparent.

3.3.1 Diffusion of conservation practices in agriculture dominated landscapes

Most of the literature on conservation practices in rural landscapes is about reducing the agricultural impacts on land and water (Pannell et al., 2006). These include practices such as conservation tillage and development of technologies such as pest resistant crops (Pannell et al., 2006). It appears that most of the diffusion of innovation research in conservation practices was focussed on practices which had involved economic gain (Vanclay, 2004). This

pattern is also evident in early diffusion studies in agriculture (Clearfield & Osgood, 1986; Nowak, 1982). The hybrid-corn study was such an example of an innovation with a clear economic gain. On the other hand, there was limited research about practices such as riparian restoration which provide minimal financial gain for farmers and rural landowners (Vanclay, 2004).

However, more recently, there are increasing studies available about diffusion and adoption of conservation practices introduced in rural landscapes. Such research has concentrated on exploring why conservation practices are not readily accepted by rural landowners. For example, Padel (2001) explored the application of the diffusion model to the adoption of organic farming. She found that diffusion of organic farming was in its early stages and the more recent converters to organic farming had characteristics similar to the early adopters in other innovations. She concludes that the diffusion model could be used to understand the diffusion of organic farming as well as to understand the decision to convert to organic from conventional farming.

There have also been studies using the diffusion of innovations in extension practices (Black, 2000; Padel, 2001). Extension can be explained as activities relating to education, technology transfer, human resource development, behaviour change and awareness of information and transfer of it (Pannell et al., 2006). Black (2000) describes that the diffusion of innovations model is the same as the linear top-down transfer of technology strategy in extension. The idea behind the strategy is once the early adopters or farmers (progressive farmers) adopt the innovation, then the other potential adopters would soon follow their example. There have been justified criticisms to this strategy as authors have argued that this approach is too simplistic and that insufficient attention has been given to the social, economic and environmental consequences of the innovation (Vanclay & Lawrence, 1995).

It can be argued that there are significant differences between conservation practices and innovations discussed in other diffusion studies. Conservation practices are less attractive to members of a rural society than an agricultural innovation, for example new machinery. Non-adoption rather then adoption of such practices is also deemed easier for farmers and rural landowners (Padel, 2001). The resistance from these members are partly due to the complexity of the practice and need for major changes; higher uncertainty and risk, incompatibility with existing practices, greater unprofitability and less flexibility in management (Guerin & Guerin, 1994; Padel, 2001). For example, one study found that subsistence farmers in developing societies could not adopt a conservation practice based

solely on the information received and adoption was highly dependent on costs and practicality of managing the practice (Napier, 1991).

In a rural setting, the adoption process is dependent on expectations or subjective perceptions rather than the objectiveness of the conservation practice (Atwell et al., 2009; Pannell et al., 2006). Expectations or subjective perceptions of land owner's depend on the information process, social environment and the characteristics of the practice (Pannell et al., 2006). In addition, it has also been discussed that awareness and education of environmental issues concerning ecosystem degradation can contribute to the adoption of conservation practices (Curtis & De Lacy, 1996; Curtis & Robertson, 2003).

Studies have suggested that more than half of the variance in the rate of adoption can be related to the five perceived attributes of the innovations; relative advantage, compatibility, complexity, trialability and observability (Kremer et al., 2001). Similarly, these attributes were found to influence the rate of adoption of conservation practices. For example, Kremer et al. (2001) found that farmers in Iowa, USA, did not adopt N-Trak nitrogen soil test because they did not perceive the benefits from the innovation and the test was not compatible with the farmers' economic objectives.

In addition, the diffusion process is influenced by factors such as informal networks between landowners, relationships between landowners and agencies promoting the practice, personal goals such as financial gain or social acceptance, compatibility with existing set of practices and the complexity of carrying out a practice (Atwell et al., 2009; Jacobson, Sieving, Jones, & Van Doorn, 2003; Padel, 2001). For example, Jacobson et al. (2003) conducted a study to assess farmer's attitudes towards bird conservation on organic and conventional farms in Florida, USA. Their results indicated that farmers' socio-demographic background, characteristics of the farm, social networks, barriers in adoption such as financial barriers and participation in social organisations were influential in the adoption decision of farmers. In another study, Curtis and Lacy (1996) emphasised the significance of landcare groups to the contribution to sustainable resource management in rural North-east Victoria, Australia.

3.3.2 Use of diffusion framework in riparian restoration

Currently, in rural communities, conservation practices such as riparian restoration practices are not integrated into the rural culture (Atwell et al., 2009). As previously stated, there is not much research on the application of diffusion for practices such as riparian restoration. Katz (1999) points out that in many of the diffusion related studies, there is no direct mention of

'diffusion' although there are aspects of diffusion framework evident in the research. This is true for many of the ecological restorations papers that discuss the adoption of conservation practices among rural landowners but do not directly use the diffusion of innovation theory.

It has been questioned whether the diffusion framework can be applied to more complex practices. However, Norman (1982) argues that the question was not whether the model can be used for conservation practices, but whether there is any utility in the application of this model. There is evidence to suggest the use of this framework may be helpful in understanding the spread and adoption of conservation practices (Atwell et al., 2009).

The study conducted by Atwell, Schulte and Westphal (2009), that explores the potential for perennials in the U.S Corn Belt, is a good example of a study that applies diffusion model to conservation practices. Their study was focussed on understanding the conservation decisions of rural landowners in three watersheds. Their results indicated that adoption decisions were influenced by the interplay of various factors at three levels of the system; society, community and individual (Figure 12). Successful diffusion of perennial practices must consider these factors. Furthermore, the study concluded that decision to adopt is based on: compatibility with farm priorities, practices and technologies; community-level reinforcement through social networks and support structures; and well-targeted, flexible incentives and regulations from institutions (Atwell et al., 2009).

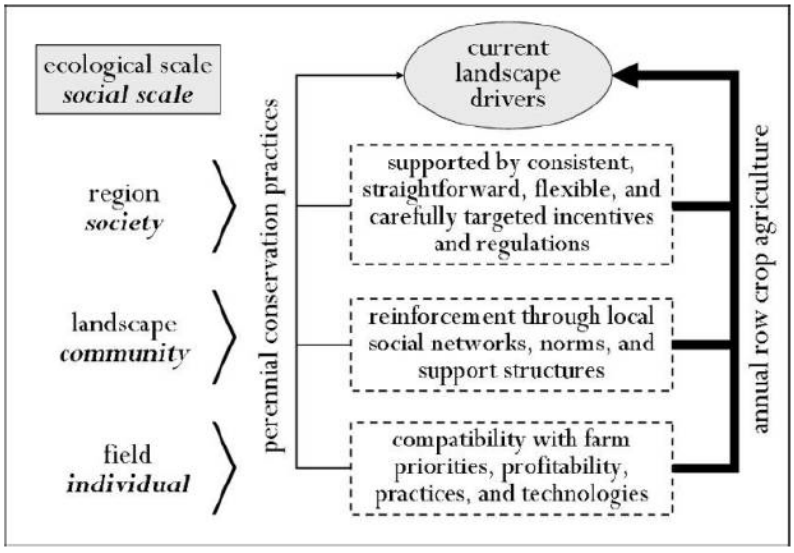

Figure 12 The factors found influencing conservation decisions of landowners (Atwell, et.al., 2009).

There are other studies where there is no explicit use of diffusion model but explores the adoption of riparian restoration initiatives. One such example is the study conducted in Goulburn Broken Catchment of north-east Victoria, Australia. This study explored landowner adoption of current recommended practices expected to improve management of river

frontages (Curtis & Robertson, 2003). The results of the study concluded that community education was an effective strategy leading to adoption. The research reported that higher adoption of current recommended practices (for example, fencing, riparian planting) correlated with increased knowledge of river frontage and factors affecting river; higher importance given to environmental, social and cultural values of frontage; and the effectiveness of the practice (Curtis & Robertson, 2003). It was also found that cost was a one of the factors influencing non-adoption especially by farmers.

Similar findings were also apparent from a study conducted to assess community capacity for riparian restoration. The aim of the study was to assess whether the National Riparian Lands R&D Program had built capacity to conduct riparian restoration in the long term. This research was based on different case studies (Thomson & Pepperdine, 2003). In this study, 'capacity' was defined as the capability to participate, learn and act and the research explored different dimensions of 'capacity' that influenced riparian restoration. The use of 'capacity' in this study could be likened to the adoption in diffusion models. The research found various factors as influencing the 'capacity', which include economic conditions, awareness, community support, community networks, complexity of practice, perceptions and values, community mechanisms, cooperation between agencies, financial capability and institutional capacity (Thomson & Pepperdine, 2003).

It is evident that the findings of the above studies show factors that are similar to those identified as influencing the rate of adoption of an innovation previously (Figure 10). Although the use of the diffusion framework was not apparent in these studies, there are conceptual elements of the diffusion theory evident in these studies. In conclusion, there are examples that indicate diffusion of innovation theory may be applied to understand the spread of conservation practices such as riparian restoration.

4 METHODOLOGY

4.1 STUDY AREA

The study was focussed in the Lake Ellesmere (Te Waihora) catchment. The lake is located south of Christchurch in the Canterbury region of South Island, New Zealand (Figure 13). The lake catchment was selected as it is an important wetland system with cultural, environmental, social and economic significance. The lake conditions have been described as deteriorating mainly because of the intensification of agriculture in the region. There are significant conservation practices in place to restore the degrading waterways and riparian restoration is one of them.

Waihora Ellesmere Trust's riparian restoration work was chosen as the subject for the study as WET had been operating in the catchment since 2004. This study subject was also chosen due to pragmatic reasons as Lincoln University has close affiliations with WET because of their restoration work. Therefore, it was identified that this would perhaps facilitate accessing available information and getting in contact with key people.

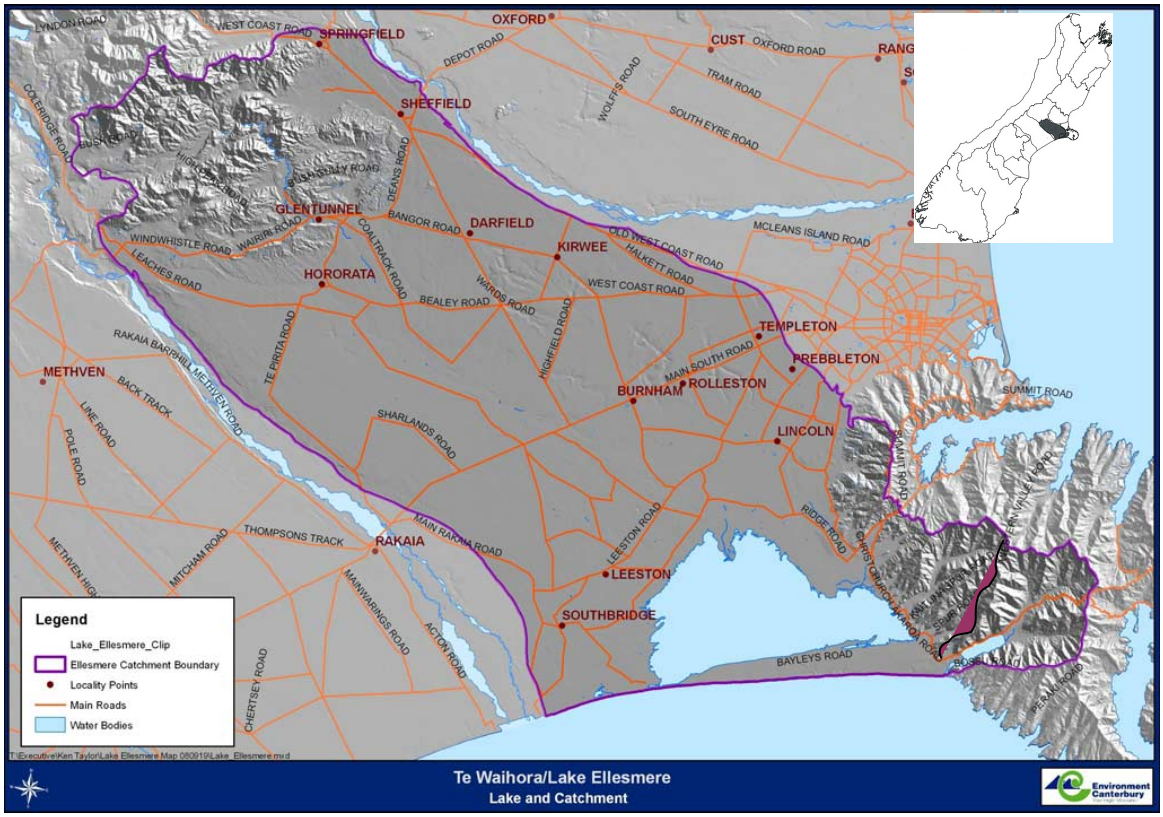

Figure 13 Location of study area, Te Waihora/Lake Ellesmere catchment showing the settlements in the region. Lake Forsyth catchment is seen at the bottom right hand corner (Waihora Ellesmere Trust, 2009b).

4.2 METHODS

This study was conducted using qualitative research methods. A qualitative approach was used as it was observed from the literature that diffusion of conservation practices is a poorly researched area. Qualitative research is useful when important variables to examine are unclear and can be useful for exploratory research (Creswell, 2009). Atwell, Schulte and Westphal (2009) identified that the qualitative approach is more appropriate for diffusion studies as it was a social phenomenon and a complex issue. Therefore, it was identified that a qualitative approach could aid in obtaining a better understanding of the aspects in the diffusion of riparian restoration.

There were two main sources of data used for the study. The initial data collection involved secondary data sources. Primary sources of data involved interviewing key people to get an insight into riparian restoration initiatives. Two types of data collection were used so that a cross check of the information could be done. As recall bias has been identified as an issue in diffusion studies, it was felt that the use of both secondary and primary sources would minimise such issues associated with the recall of information.

The initial data was collected mainly from documents of WET. It is of note that much documentation in the first few years of the Trust's formation has been lost with changes to administration and staff replacements. The available WET documentation that was consulted included project overviews, funding applications, minutes of meetings, riparian restoration programme report, WET's community strategy and other administrative documents. WET's current manager was consulted to clarify information in these documents. It must be noted here that even though WET has been conducting restoration for several years, a complete list of the riparian restoration sites and details with regard to those sites were not documented. Therefore, the previously stated documents were thoroughly examined for any useful information with regard to existing riparian sites.

Data from primary sources was collected from interviews with key informants. This study used non-probability sampling approaches which are often used in qualitative studies (Atwell et al., 2009). The main reason for this type of sampling was so that informants would be chosen from those involved in the WET's riparian restoration initiatives. Initially, interviews were selected using purposive sampling. The main stakeholders in riparian restoration were identified through discussions with WET staff, the main stakeholders in riparian restoration. Purposive sampling was then used to select the initial informants to be interviewed. Initial informants interviewed were from Trustees of WET, who had conducted restoration work for

several years. Through these informants, snowball sampling was used to select more informants. This sampling method led the way from one referral to another. The informants interviewed and their backgrounds are given in table 4. It should be noted that not all informants identified from snowball sampling could be interviewed because of time constraints. In addition to the interviews, there was a one day field visit to some of the most significant restoration sites. This trip was organised by WET and it was part of an information session about riparian restoration especially how it was being conducted at these sites.

Table 4 List of key informants interviewed

Informant	Occupation	Background
SDC Staff	Reserves supervisor	• Has been working in SDC for six years mainly in charge of the maintenance and management of public reserved • Key informant for restoration sites administered by SDC • A key actor in the Mitchells Road mudfish site
Prominent WET Trustee	Retired farmer	• Long family history in catchment • One of the founders of Harts Creek Streamcare group • Does independent riparian restoration work on his land • Was among the early Trustees • Was involved in the early riparian restoration work of WET
ECan Staff	Senior Resource Care Co-ordinator	• Involved in the ECan's Living Stream Programme • Been working in the catchment for several years • Provided advice and technical assistance in formation of the Harts Creek streamcare group • Involved in many of WET's riparian restoration sites
WET Staff	Riparian Restoration consultant / WET Trustee	• Originally training in forestry • Trustee for over 8 years • Has been conducting riparian restoration work since 2007
Prominent WET Trustee	Commercial fisherman	• Long family history in the catchment • Conducts commercial fishing in the Lake Ellesmere • Does independent riparian restoration work on his land • Is among the early Trustees • Involved in the initial riparian restoration work
ECan Staff	Zone facilitator – Water Management	• Former WET coordinator • Was involved in the earlier riparian restoration projects (between 2006-2008) • Presently, facilitating the implementation of the CWMS
Private landowner	Retired farmer	• Owns a cattle farm near to edge of lake • One of the riparian restoration sites on his land

The semi-structured interviews followed an informal discussion style. The informants were requested to discuss their knowledge of how the riparian restoration sites formed and hence a discussion followed. Some of the key questions used to lead this discussion are provided in table 5. A recorder was used in the interviews and it was not observed that this affected the interview process adversely, perhaps because the interviews were conducted in an informal setting and manner. It should also be noted here that the researcher was aware that some individuals may be hesitant in giving information to an external person unfamiliar with the farming context. It was also noted that the interviewer's ethnic background and language may be a barrier to information reception. However, these issues were not observed to be a significant obstacle during the interview process.

Table 5 Key question posed to the informants

Key question posed to informants
• Where are the sites located? • Why was this particular site chosen? • Who initiated the restoration project? • How was the initial contact made about restoration? To whom? • How did WET get involved? • Role of other partners? • Observations about site locations

A database was created in Microsoft Excel (MS Excel) to enter the compiled information about the riparian restoration sites. The entries were from data collected predominantly from secondary sources but was cross checked with data from primary sources. It was decided to use MS Excel as it could provide a table containing important information of sites in one sheet. This would make the analysis easier and less time consuming. A map of the riparian restoration sites was developed and this was used to analyse any significant patterns in the distribution of the sites.

The information gained from the interviews was transcribed verbatim for analysis. This information was used to develop a short history of how each site was formed. This background information was once again cross checked with the data entered in MS Excel. The transcribed information was repeatedly analysed to identify recurring themes with broader overarching themes identified.

4.3 LIMITATIONS

One of the main limitations in this study was to do with the selection of key informants. There were not enough key informants represented in this study to provide a complete reflection of the spread of riparian restoration practice. Key informants interviewed included some of the most significant people involved in WET's restoration initiatives. However, there was inadequate representation of local landowners on whose land riparian restoration has been conducted.

It was identified that the best way to communicate informally with landowners was to get a referral from another local in the community. This was the methodology used in this study. However, waiting for referrals and organising of interviews with landowners was found to take more time than previously anticipated. Therefore, it was decided to pursue the analysis with the interviews already conducted due to time restrictions of this dissertation. Interview with informants was also disrupted because of recent earthquakes in Canterbury and the recurring aftershocks. Individuals were hesitant to provide the time for interviews because of the disruption to their daily life and commitments related to the before stated events.

This study focussed on riparian restoration work conducted by WET. Therefore, it did not consider riparian restoration initiatives of independent individuals and other community groups in the Lake Ellesmere catchment. This has been noted as another limitation of this study.

There was also the issue of recalling information about past experiences. Key informants were confused at times with remembering time periods of incidents and how the initial communication about restoration occurred. Rogers (2003) states this recall problem as a limitation in diffusion studies.

5 RESULTS

The results of the study are presented as five sections. The first section provides general information about the WET riparian restoration sites. The second section outlines information about the initiation of the sites, including patterns in the formation and possible reasons for conducting restoration. The third section describes some of the major factors that may have influenced the selection of the riparian restoration sites. The fourth section outlines the different communication pathways through which information about riparian restoration had spread. The last section briefly discusses some of the factors which may have influenced the adoption of riparian restoration initiatives.

5.1 INFORMATION ABOUT THE RIPARIAN RESTORATION SITES UNDERTAKEN BY WET

Waihora Ellesmere Trust has undertaken riparian restoration at 21 sites in Lake Ellesmere catchment since 2004. The location of these sites is provided in Appendix 1. The background to the initiation and formation of the individual sites was compiled from both the primary sources of data such as interviews with key informants as well as secondary sources of data such as documents from WET. Appendix 2 contains this information and gives a brief introduction to each site. The information gathered about the sites was also compiled as a database of the riparian restoration sites, which is not included. A summary of this spreadsheet is provided in table 6. The database contains detailed information about the sites, such as ownership, planting period and partnerships formed.

It can be observed from the information compiled that out of the 21 sites, 11 sites are on public land (mostly SDC land) and six on private land (Appendix 1 and Table 6). It can also been seen that four of the sites are on land under both public and private ownership. Most of the plantings were conducted between January 2009 and December 2010. The sites were initiated by different groups and the work was carried out for different reasons.

There was no significant pattern noticed about the distribution of the sites other than that most of the sites were observed to be clustered in the lower catchment close to the Lake Margin (Appendix 1). The location of one site, Mitchells Road Mudfish, was observed to be the only site in the middle part of the western end of the catchment with none in the upper reaches of the catchment (No. R12 in Appendix 1).

Table 6 Information on WET's riparian restoration sites

MAP ID	PROJECT/SITE NAME	OWNERSHIP		PLANTING PERIOD	INITIATION	PARTNERSHIP
		Public	Private			
R1	Ahuriri Lagoon	ECan		2004	WET	_
R2	Boggy Creek	SDC	Inwoods/ Fish & Game	2009-2010	Fish and Game	WET, Fish and Game, SDC, Inwoods
R3	Chamberlains Ford	SDC		2008 - 2010	Green Footprint	Green Footprint partnership (SDC, YHA), WET,Landcare Research was a partner in the early period
R4	Coes Ford	SDC		2005 - 2007, 2010	Green Footprint	Green Footprint partnership (SDC, YHA), WET,Landcare Research was a partner in the early period
R5	Days Road Drain	SDC		2009	WET	WET, Ecan,SDC
R6	Donalds Farm		G.Donalds	2009-2010	Clem Smith (WET Trustee)	WET, Donalds, NZPI/PIA
R7	Hastings Terrace Stage 1	SDC/Crown	S Hastings	2010	ECan	WET, Hastings
R8	Hastings Terrace Stage 2		S Hastings	2010	Stuart Hastings	WET, Hastings
R9	Knight's Stream		V Pender	2009	ECan	WET, Pender, Ecan
R10	Leeston Creek	SDC		2008-2010	Leestons Residents Association	Leeston Residents Association, SDC, WET
R11	Marshall's		D Marshall	2010	D Marshall	WET, Marshall, Leeston Residents Association, Streamcare group, SDC

MAP ID	PROJECT/SITE NAME	OWNERSHIP		PLANTING PERIOD	INITIATION	PARTNERSHIP
		Public	Private			
R12	Mitchells Road Mudfish	SDC		2009-2010	SDC	WET, SDC, DOC, WWF, GHD, Sandford (adjoining landowner)
R13	Ogg Drain		R Ford	2010	R Ford	WET, Ford
R14	Osterholts Rd	SDC/Crown		2010	OTTR Streamcare Group	WET, OTTR Streamcare group
R15	Pakoau Stream stage 1,2,3	DOC		2009-2010	Ngai Tahu and DOC	WET, Ngai Tahu, DoC, Community Max, Leaseholder
R16	Selwyn Waikirikiri Delta		Ngai Tahu	2009-2010	Ngai Tahu	WET, Ngai Tahu, Community Max
R17	Silverstream	SDC		2010	WET	WET, Ecan, SDC
R18	Skilling's/Leeston Stream stage 1	SDC	M Skilling	2009	WET	WET, Skilling, St Andrews College
R19	Skilling's /Leeston Stream stage 2	SDC	M Skilling	2010	WET	WET, Skilling
R20	Stones Drain	SDC		2010 ?		WET, Ecan, SDC
R21	Tramway Reserve	SDC		2008	WET	Department of Conservation, WET and Tramway Reserve Trust

5.2 SITE FORMATION AND ATTRIBUTES

The analysis of the interviews with key informants and the secondary sources revealed significant information about the formation and attributes of the various riparian restoration sites. These include patterns in their formation, ownership of land, geographic location and accessibility.

SITE FORMATION

The riparian restoration sites were formed in various ways. Some of the sites were developed as part of programmes such as the Green Footprint Project, whereas other sites such as the Silverstream site were formed because it was identified as a priority waterway for the WET's riparian restoration programme. However, most of the riparian restoration sites appear to have formed not as part of a strategic selection process. A key SDC informant described,

> "*it is funny how these projects start off from nothing and it is quite unusual, so it does not seem to be strategically planned…*" .

Perhaps, this is best exemplified by the Mitchells Road mudfish site. This site, originally comprising an area of willow, gorse and other predominantly exotic weed species, was initiated because an adjoining landowner bulldozed the area thinking it was part of his land. The error was discovered by the Department of Conservation who regularly monitored the mudfish in this area. This led to discussions with the stakeholders on the mitigation of the site. It is probable that if this accident had not occurred the site would have remained largely in its original degraded state and of low priority for SDC.

It appears that biodiversity and cultural values were significant in formation of some sites. This was evident from the compiled database and backgrounds to the site. For example, the Selwyn Waikirikiri Delta site held significant cultural values for Ngāi Tahu. This was given importance when the site was considered for riparian restoration work. Another example is the Mitchells Road mudfish site where the stream was a significant habitat for Canterbury Mudfish. In addition, from the interviews with key informants it appears that there were key riparian restoration objectives identified for all sites retrospectively, regardless of how the sites were initially formed. These objectives as expressed by key informants are outlined in table 7.

Table 7 Riparian restoration objectives expressed by key informants

Riparian restoration objectives
To enhance biodiversity values of the site
To improve water quality and quantity of the waterways
To reduce invasion of exotic weeds and improve maintenance of waterways
To enhance the aesthetic qualities
To reduce erosion and sedimentation
To improve mahinga kai
To educate and create environmental awareness among the members of the community
To use site as a demonstration for riparian restoration
To promote involvement of locals in conservation practices
To promote farming as a 'greener' practice

OWNERSHIP OF LAND

There appears to be more riparian restoration sites in public land than private land. Only six of the restoration sites were on land entirely in private ownership (Table 6). It should also be noted here, as indicated by a staff of WET, that landownership was a complex issue as a site may be on private land, but may have a public component in it. This is usually due to the stream being considered as public property.

One key informant suggested that he thinks that riparian restoration took place more on public lands because of the timing of the diffusion of riparian restoration initiatives. His view was that these riparian restoration initiatives took place at a time when farming was facing economic hardships. Farmers may have shown reluctance to undertake any work (such as fencing) that could cost them additional financial burden. In addition, restoration may need to be conducted at the expense of valuable farming land that could be used for grazing. This informant thought this could have impacted riparian restoration to be focussed more on public land as to avoid pressuring farmers into retiring land at that time.

There was also the view formed by the restoration consultant as well as key government informants that at times it was harder to work with private landowners and form a partnership. It was inferred from the interviews that public land was preferred to private land in order to avoid the complexity and difficulties encountered with private landowners. Many of the key informants perceived that sometimes carrying out a dialogue to interest a farmer was a lengthy and complex process.

In relation to this issue, another key informant expressed that normally it is easier to work with an experienced farmer with years of farming than a young farmer who had just started his career. In his view, the rationale behind this is that a farmer starting his career would have other priorities such as making profit and establishing his farming business. On the other hand, a farmer about to retire or has retired has a stewardship view of the land and is interested in giving something back for future generations. It was also expressed that more experienced farmers are perceived as being better committed to restoration. A respectable local fisherman, who was from a family with a long history in the catchment, expressed similar concerns. He expressed that sometimes people do not have the time to commit to practices such as riparian restoration.

Practicality and accessibility were also suggested as reasons for choosing public land over private land. This would be further explored in the other factors. There were also suggestions that sometimes private landowners might not be satisfied in giving access to planting workers, mostly the volunteers such as rehabilitating prisoners.

GEOGRAPHICAL LOCATION

Geographical location of the site was another factor observed as influencing site location. Most of the sites appear to be located at the lower end of the catchment closer to the edge of the lake (Appendix 1). The reasons for this distribution were explored in the interviews. The analysis of the interviews also suggested that some of the locations may also be influenced by proximity to other sites.

The location in the catchment appears to be an influential characteristic of the site. Some sites are located on the lake shores while some are a little further inland. There were five sites on the eastern boundary of the catchment and of these sites the furthest one inland is near Halswell (R9, Appendix 1). There was only one site (Mitchell Road mudfish) that is located in the middle catchment near the Hororata River (R12, Appendix 1).

There were few suggestions for the reasons behind this distribution. A restoration consultant suggested that sites may have been located closer to the edge of the lake because the lower catchment contains numerous streams and drains. Most of the streams are spring-fed and the Selwyn River flows throughout the year in this part of the catchment. He explained it as follows,

> "*so if you are dealing with a riparian programme, most of it is going to be here because that's where all the water is…*".

A former WET coordinator expressed similar thoughts and stated that the lower catchment contains a myriad of streams and drains so it was more of a question of where to start. They both suggested that a location with a good supply of fresh water is needed to successfully implement a riparian restoration site.

The anomaly in the distribution was the Mitchells Road mudfish site. The restoration consultant explained that at that site even though the site was located in a dry land area, there was enough moisture and deep fertile soils to support riparian restoration. He also stated that the site provided an opportunity for WET to do restoration work inland in the middle catchment. He explained it as follows.

> *"….to have more contact up in the catchment, I saw all these great work we are doing down here (lower parts of the catchment) in all the various bays, we didn't have anything inland. And that's where most of the "problems" come from. It's where all the intensification, all the water is going into, this beautiful porous soil, and then it comes back out here.."*.

Similar thoughts were shared by another WET Trustee. This Trustee informed that at Canterbury's Agricultural and Pastoral (A&P) Show people often state that they live outside the Ellesmere catchment in Darfield or Rolleston. However, when they are asked to put a pin on where they live, suddenly it occurs to them that they live in the catchment. Therefore, WET realized that they had to make the contact with locals of upper catchment. Mitchells Road mudfish site came along at the right time for WET.

A key informant from a government agency suggested that it may have been because there is private land than public in the lower part of the catchment. He also explained that most of the time it is harder to get funding for smaller projects (with smaller land area) and therefore groups like WET need to have larger areas to secure funding. This, as he explained, may be related to the sites being located at the lower end of the catchment as there is more land area available there. This factor also relates as well to the ownership category explained before.

The respondents also identified that the proximity of the site to other restoration sites may be another factor influencing location. For example, riparian restoration work done at the creek in Leeston was the same waterway which flowed through the Skillings site and Tramway Reserve. Chamberlains Ford and Coes Ford were decided because they wanted to develop a corridor between the sites. Other reasons such as funding, efficiency and accessibility may influence why proximity is important.

ACCESSIBILITY

Accessibility was another factor observed to be influencing location. Accessibility here can be defined as the ease of road access to the site. This is also related to the ownership of the land. Many of key informants indicated that sites were located for practical reasons such as accessibility. The access pathways, such as a good road network, were stated as being important. For example, Boggy Creek was a site which was easily accessed even though it was on a private land. It was also expressed by key informants that public land was preferred because most sites in these locations are easily accessed by public roads. These include sites such as Days Road Drain, Chamberlains and Coes Ford.

Accessibility was also a factor considered in selecting sites that could potentially act as demonstration sites to the public. Informants from government agencies suggested that sites are more useful if they can be used as a demonstration site to educate the public about restoration as well as enhance knowledge about the biodiversity. Therefore, they explained that locations that can be easily accessed as well as visible to passing road users are more preferable. Mitchells Road is expected to be developed as such a site. The Ngāi Tahu site, Selwyn Waikirikiri Delta, also have such long term plans.

5.3 COMMUNICATION PATHWAYS

The five main groups identified as actors in the restoration process were the government agencies, WET, Ngāi Tahu, private landowners and community groups. The Green Footprint project was identified as a key party but they include partners from the previous groups and therefore were not included as a separate group. It should also be noted that there are sub-groups within each main group.

GOVERNMENT AGENCIES

Government agencies include three main sub-groups, Selwyn District Council, Department of Conservation and Environment Canterbury. A restoration consultant expressed that the partnerships formed between these groups and the wider community is crucial for the diffusion of information. As he explained:

> "*And they are on the farms and dealing with different landowners at times and they are spreading the word further so in some ways it works quite well.*"

A lot of the restoration sites are on SDC land and this provided them the opportunity to be involved in this work. There were also instances where SDC took the initiative to communicate information to WET about potential restoration sites. These include sites such as Mitchells Road mudfish site (R12, Appendix 1). The partnership between SDC and WET seemed to have been formed with the development of Green Footprint projects.

Environment Canterbury is identified as another key group. They have also been undertaking riparian restoration work in the catchment and hence had knowledge of other similar work in these areas. ECan was the key player in initiating sites at Hastings Terrace (R7 & 8, Appendix 1) and Days Road Drain (R5, Appendix 1) and also key partners of some other sites. As an ECan staff explained,

> "*I knew WET had the money, so I knew they had money to spend and they were looking for sites. So they needed sites. So it was just putting two and two together…*"

Department of Conservation is another actor apparent in some of the riparian restoration sites. DOC administers around 35 percent of lake at the lake margin (Te Rūnanga o Ngāi Tahu & Department of Conservation, 2005). One of the earliest restoration sites, the Tramway Reserve, belongs to DOC and thus they have been involved in restoration work as early as 2007. In this regard, they have become partners with WET and other community groups in vicinity of their lands.

WAIHORA ELLESMERE TRUST (WET)

Waihora Ellesmere Trust (WET) is another group identified as being influential in the network. WET has been doing work in the catchment for over six years and has been very active over the last two years. Over the years, WET was observed to have built relationships between many of the other groups and had several key contacts. As one of the private landowners explained local people are aware of the work WET is conducting and hence has approached them about doing similar planting work in their properties. In addition, many of the WET Trustees are members of the social communities in the catchment. Some of them are undertaking independent riparian restoration work on their private lands. Furthermore, it was observed that there are key actors among the Trustees that had a major role in spreading of the riparian restoration work. In some cases, riparian restoration sites have been inspired by the work done by some of these key Trustees. For example, Donald's site was inspired from the work conducted by his neighbour, a WET Trustee.

COMMUNITY GROUPS

Community groups have been identified as being involved in many of WET's riparian restoration initiatives. Streamcare groups, environmental clubs and Resident Associations are just some of these community groups. These groups were observed to be influential in the informal network. Most of these groups are composed of members from their local communities.

Streamcare groups have influenced the initiation of some sites such as Osterholts Road and the Marshall sites. In addition, the Marshall site (R11, Appendix 1) is an example of how the streamcare groups aided in diffusing information about riparian restoration. Streamcare groups have conducted independent riparian restoration work in the catchment. Key informants, also locals from the catchment, identified that the local people respect and acknowledge the work these streamcare groups are conducting. Riparian restoration at Harts Creek Reserve (not a WET site) is a good example of successful restoration work conducted by a streamcare group (Harts Creek Streamcare group). They have been conducting work at Harts Creek for over eight years. One of the leading members of this group is also a prominent Trustee of WET. The work of this group has inspired riparian restoration at other sites. For example, at the Skillings site the landowner (Murray Skilling) had known about the Harts Creek project through his community and had visions to carry similar work at the stream in his property. His vision came into action when WET provided him the opportunity to get it going. Interviews with farmers did indicate that news of the work being done at Harts Creek had spread through the different channels and hence most locals had knowledge about it.

Leeston Creek was another example of an initiative taken up by a community group (Leeston Resident's Association). They had heard of the work done by WET through other channels in the network and approached WET, initially at WET's Leeston A&P Show stall, about doing work in the creek.

NGĀI TAHU

Ngāi Tahu owns some of the land and has long term leases on other land in the lake catchment. They have been conducting riparian restoration work independently in some of their land in the catchment. For example, they initially started the restoration work in the Selwyn Waikirikiri Delta site. The restoration consultant working for Ngāi Tahu is the same person doing work for WET. Furthermore, a Ngāi Tahu Lake Management Board officer is also a former WET coordinator and lives near Coes Ford. This appears to be providing a link between these two groups as well as other agencies. Ngāi Tahu has a partnership built with

Department of Conservation and this is set out in their Joint Management Plan for the lake (Te Rūnanga o Ngāi Tahu & Department of Conservation, 2005). This partnership seems to be influential in communicating information on riparian restoration to the right people. For example, this was the case at the Pakoau Stream site.

PRIVATE LANDOWNERS

Private landowners also play a part in communicating information on riparian restoration. These landowners usually have a contact within the other groups mentioned above. However, they also appear to act independently as communication sources. For example, in the Marshalls site, the landowner was a streamcare member but acted in his own capacity to address his concerns about his land and desire to do some work there. He used the contacts he had in the community to pass along this information so that it could reach the right people who could act on it.

For example, this is how one keen member explained it:

> *"This networking…I sort of liken it to the Maggie Barry's TV Garden Show, a very popular Television programme. She was quite a personable person and she did lot of interviewing people about gardens. And a lot of household New Zealanders were very interested and that really started a whole wave of people sharing their knowledge with their gardens and it's a great fundraiser. It still goes on. Local community groups earn money by having a day where they might have six gardens in that area, they advertise it and you pay 10 dollars per day (like a field day). And it is still very popular."*

In addition, there appears to be key contacts/members among these groups that work as the core for information diffusion. These members appear to be well-recognised and trusted people in the community and their names are mentioned in almost all interviews done. For example, a key informant expressed this as

> "*You need to get a referral from someone who they trust, like if you want a fence put up…."*

5.4 ADOPTION OF RIPARIAN RESTORATION IN THE CATCHMENT

This topic was not explored to a great length in this study. However, key informants made a number of general comments on the adoption of riparian restoration. Similarly, the interviews identified many factors that may act as barriers for adoption of the practice.

ADOPTION

It was identified that there were various issues contributing to the potential adoption of riparian restoration. These are outlined below:

Personal interest in the conservation practices

It was expressed that riparian restoration is more acceptable if the individual or groups have a keen interest in such conservation practices. For example, a retired farmer explained this rationale as follows:

> *"I was interested in trees and plantings and that sort of thing. So I have done some planting but my older brother has not done any planting. But it is sort of an indication of farmers in general, you get some that are more interested in different aspect of things."*

Another informant, from a family with a long history in the catchment, explained that his interest in riparian restoration developed because of his interest in native birds. He explained that he was convinced native vegetation would attract more birds but he mentioned he might need to wait for some years to see the result and it would be worth it. Aesthetic values and conservation values upheld by individuals appear to be influential in the decision making process.

Voluntary participation

Voluntary participation means an individual gets involved in riparian restoration of his/her own will without the full pressure of a regulatory body. Key informants trying to establish the practice of riparian restoration in the catchment emphasised voluntary participation as an important issue for adoption. They stated that in their work they found that such practices are accepted better if people are not forced to take action or the practice is imposed on them. It was also identified that acceptance is more guaranteed if government agencies do not apply rules on individuals because they tend to rebel.

A retired farmer explained how he started working in a streamcare group and expressed that

> "*ECan, they deserve a pat on the back, just the way they went about it. Because they could have said to us, hey that is not good enough what is happening here…but they came and talked to us and got us involved."*

However, a government informant expressed that at times government agencies operated as the control units and action is often taken through enforcement of rules. He stated that it was unfortunate that the agencies overlook the significance of voluntary participation especially in rural communities. It was identified that a practice would be more accepted if individuals did

it voluntarily with the advice of agencies and regulated the practice independently. For example, a government informant expressed that in this way individuals take a personal interest in the practice and take on greater responsibility for the work.

Reinforcement from government agencies and local groups

Reinforcement was identified as one of the major factors influencing adoption. Reinforcement comes in many forms such as face-to-face discussions, encouragement and support structures.

Informants involved in the riparian restoration sites expressed that face-to-face discussions were crucial when working in rural communities. A personal approach and an understanding dialogue were needed to earn trust of members and convince them of the benefits of this practice. Informants explained that a person would need to address community members in simple language and explain things in a manner they understand. People need to be made aware of the benefits and disadvantages of a practice but it should be done in a light manner. It would be difficult for an idea to be accepted if it sounds too technical and complex. It was also viewed that a practice gets accepted better if the people are informed about the many others doing similar work in the catchment. As one government informant explains that it was,

> *"understanding that there is a group who is working on it, the wider catchment is involved, and everyone is working on it. So it is not just him."*

It was also perceived that encouraging words aid in accepting the riparian restoration process. One of the informants from a government agency explained that potential members adopting such practices need some form of encouragement from time to time. This is to let them know that these agencies are supportive of their work and to praise the work being conducted. An informant doing riparian restoration in the catchment applauded a government agency for their efforts. He stated that,

> *"So it was a big help working with them because they encouraged us all the way along and they didn't say you got to do that and they made suggestions. They couldn't have been better to work with."*

The need for a social support structure was apparent from the interviews with the key informants. Members of the community were observed to have adopted riparian restoration if these support structures are available. A support structure could be in the form of a coordinator assisting with bringing together all relevant partners to initiate a project. It was identified that often farmers find it intimidating to bring all stakeholders on board for an individual project. It is helpful for them if someone can assist in carrying out these

formalities. Support structures can also come in the form of funding and expert advice. A retired farmer expressed his interest in conducting riparian restoration on his land but explained that it would not have gone ahead if WET had not assisted him with the funding as well as the technical advice.

Benefits from the practice

Potential benefits to individuals from adopting the practice as well as benefits to the environment from the practice were identified as influencing an individual's view of the practice. Informants expressed that often people want to know the personal benefits for them in adopting the practice. A key informant explained this in the following sentences:

> *"But the other thing that is a real key has to be what is in it for individuals. Because people are so busy that they are not going to be able to put their hand on their heart and think oh yes, I owe this to the community to do this. There has to be something in it for them."*

These personal benefits can include things such as the practice being an advantage for the resources consent process, work would not be a burden as it would be undertaken by someone else, funding will be available for the work and the work would aid in adding in aesthetical values to the property. One of the riparian sites, the Pakoua Stream site, provides a good example of adoption based on personal benefits. The lessee came into the partnership as Department of Conservation provided him a rent free holiday when he erected a stock proof fence.

A retired farmer expressed his reasons for adopting the practice. He explained that one of the reasons was that the restoration experts advised him that conducting planting on stream banks would eventually provide shade to the stream and prevent infestation of exotic weeds. It would then reduce the need for occasional mechanical cleaning of the streams.

Benefits to the environment also aided in the decision making. Riparian restoration has been promoted as benefiting stream and river ecosystems through enhancing biodiversity values. Many of the streams where restoration work is being done are at the edge of the lake. Informants with private lands identified that they have observed an increase in trout numbers to these streams and thought it must be the result of the plantings. Often, the advantages need to be visibly detected in order for people to accept them.

Key informants expressed that in the last couple of years farmers have become more aware of the environmental issues that arise from farming. It was stated that recently, farming has been given negative attention in the media and been addressed as "dirty dairying". A retired farmer

mentioned that people are getting more interested in conducting practices such as riparian restoration in order to clear their names. He expressed that farmers are looking for ways to give farming a better image even if they do not believe farming does have an impact on the environment. Therefore, many farmers are now involved in doing work that can increase biodiversity values.

BARRIERS

Adoption of riparian restoration should be discussed along with the barriers affecting the use of the practice. It was clearly identifiable from all the interviews that the main considerations were cost and time along with other variables. A riparian consultant explained that riparian restoration requires commitment and is not cheap. The restoration process involves site clearance (weeds, willow), planting (mostly native vegetation) and maintenance (continual replacement). The restoration also needs preventive measures such as stock proof fences and spraying. Farmers mentioned that fencing alone brings a hardship on them with financial concerns about continuing riparian restoration work. Fencing also at times cost them land that could be used for grazing.

A retired farmer, who owns land that has restoration work done, explained why he rejected a previous riparian restoration project. He explained it as follows:

> *"The rule the other group had was that the area back of the stream had to be 10 metres. Well that is a big concession to take 10 metres of your property. So we did not go with it even though the funding was there to take, including the fence and all. But I said 5 metres is a fair bit of ground, 10 metres is just too much. This much is alright* (referring to the present site), *as it is wetland anyway and there is not much we could have done with it."*

Time was mentioned as a valuable commodity that at times cannot be spared to practices such as riparian restoration. Most of the informants expressed that often farming communities have many priorities and most of them were concerned with the farming practice. As mentioned previously, restoration requires commitment and dedication.

It was also identified that often benefits from riparian restoration are not visible in the short term. This acted as a barrier to people adopting the practice. Informants explained that often plantings require a couple of years to show good outcomes. It appears that in many cases, interest diminishes with time along with the dedication and commitment to the restoration work due to the delay in observing positive results. For example, a government informant expressed previous work at the Silverstream site ceased to continue as plantings did not

appear to be aiding the water quality of the stream. The group working in that stream lost interest as results were not observed in the short term. Another informant, a retired farmer, said he was not convinced that riparian restoration would aid in reducing removal of weeds as there was no indication of it happening.

5.5 SUMMARY OF RESULTS

The analysis in this chapter found that riparian restoration practice was influenced by various factors. The formation of the restoration sites was found to be influenced by land ownership, geographical location and accessibility. Information about riparian restoration was found to have disseminated through an informal network formed between five main groups. There also appears to be key people within this network who had greater influence than others in diffusion of the practice. In addition, the results indicated that adoption of the riparian restoration practice depended on several factors. However, it was also found that some characteristics of riparian restoration made it less attractive to individuals and these acted as barriers for adoption. The significance of these results will be discussed in the following chapter in the context of the current available literature.

6 DISCUSSION

The results obtained from this study provide valuable insights into the spread of riparian restoration initiatives taken by WET in the Lake Ellesmere catchment. These results are discussed further in the context of the current literature in the next four sections. The first section discusses key general observations from the results. The second section discusses the application of diffusion of innovations theory to the spread of riparian restoration with riparian restoration as an innovation. The third section discusses the diffusion pathways observed in the catchment and its key actors. The final section summarises this chapter and discusses the practicality of integrating the diffusion framework to diffusion of riparian restoration practice.

6.1 RIPARIAN RESTORATION IN ELLESMERE CATCHMENT

There were several key general observations about the riparian restoration sites found in the results and these are discussed below.

FORMATION OF THE RIPARIAN RESTORATION SITES

Waihora Ellesmere Trust has been involved in conducting riparian restoration at 21 sites since 2004. However, the results revealed that most sites were formed between 2009 and 2010. There are possible reasons for this sudden increase in riparian restoration sites. Riparian management was identified as a priority management action in the Waihora/Ellesmere Living Lake Symposium held in 2007. Furthermore, restoration was emphasised in the future scenarios developed in the symposium for effective management of the lake (Hughey et al., 2008). As the symposium attracted many participants from diverse backgrounds this could have influenced the awareness of riparian restoration among professionals, key stakeholders and the locals in the catchment communities. Consequently, WET sought funding to implement an extensive riparian restoration programme and received significant funding in 2008. Therefore, it is likely that the availability of funding facilitated the formation of greater number of riparian restoration sites. It was also stated in the results that one reason why WET was approached to do riparian restoration was because they had available funds to utilise in conducting such work.

As stated in the results, a majority of the sites appear not to have been formed through a strategic selection process. It is clear that most of the sites were formed when an opportunity

arose for WET to carry out riparian restoration work. For example, the site background to the Marshalls site, Boggy Creek and Pakoau Stream give accounts of how WET was approached for advice on conducting work at these sites (Appendix 2). However, there were six sites that were formed as a result of initiation by WET (Table 6). WET selected some of these sites as they were identified to be in their priority catchment areas. For example, Silverstream was identified as a priority catchment area and it was decided to conduct work at this site. Similarly, this provided support for WET being involved in the Hastings site, although, the initial discussions were initiated by ECan. At other times, WET initiated a site because they saw an opportunity to carry out riparian restoration at sites where there were existing plantings done or where the landowners were keen and interested in plantings.

It can be concluded that these windows of opportunity was one of the key factors that facilitated WET's capacity to conduct riparian restoration in the past. Initially, the restoration sites were not selected on the basis of being identified as a priority catchment area. However, some of the current riparian restoration sites appear to be influenced by this priority listing. Overall, it can be stated that there was a lack of an operational system in the initial formation of the riparian restoration sites.

The analysis of the interview data revealed that there were several reasons and objectives for conducting the riparian restoration work. It was apparent that biodiversity values of a site were a significant contributing factor in its formation. This was most evident and clear at the Mitchells Road mudfish site. The results also revealed that three sites held significant cultural values to the local Maori. The values which are stated above are the existing values at the site before riparian restoration was conducted. At most other sites, key informants expressed knowledge of these values but it is not evident that these existing values contributed greatly to the formation of the sites.

The results also revealed information about the desired outcomes of riparian restoration initiatives. Often the objectives of riparian restoration initiatives were not documented except for some that were stated in WET's funding applications. Generally, funding applications require the objectives of the relevant project. In this study, key objectives of riparian restoration were revealed from the interviews with the key informants (Table 7). Most of the objectives appear to be common to all sites. It is likely that these stated objectives were explicitly discussed during the initial decision to establish a site. On the other hand, it could be that the stated objectives are the reasons as to why key informants undertook the riparian restoration work. These objectives are similar to the typology of rationales developed by Clewell and Aronson (2006) for conducting restoration activities. A combination of

technocratic, biotic, idealistic and pragmatic rationales for undertaking riparian restoration work can be identified from initiatives in the catchment. For example, some of the key informants in this study were government staff and they expressed the desire to restore water quality to a level desirable for human use. This is similar to the technocratic rationale where the reason is primarily used by government organisations and often social values pertaining to water quality is important (Clewell & Aronson, 2006). The idealistic, biotic and pragmatic rationales are implicit in other objectives such as restoring lost biodiversity values, cultural values and as mitigation for past environmental degradation. These rationales imply that individuals involved in the restoration initiatives had certain objectives in place for conducting restoration regardless of what is stated for the purposes of funding.

SITE SELECTION

The results suggest that the distribution of the sites depended on three prominent factors. These factors were grouped into three categories, mainly accessibility, ownership and geographical location (Figure 14). However, during the formulation of the data it was evident that these categories were also interlinked to some degree.

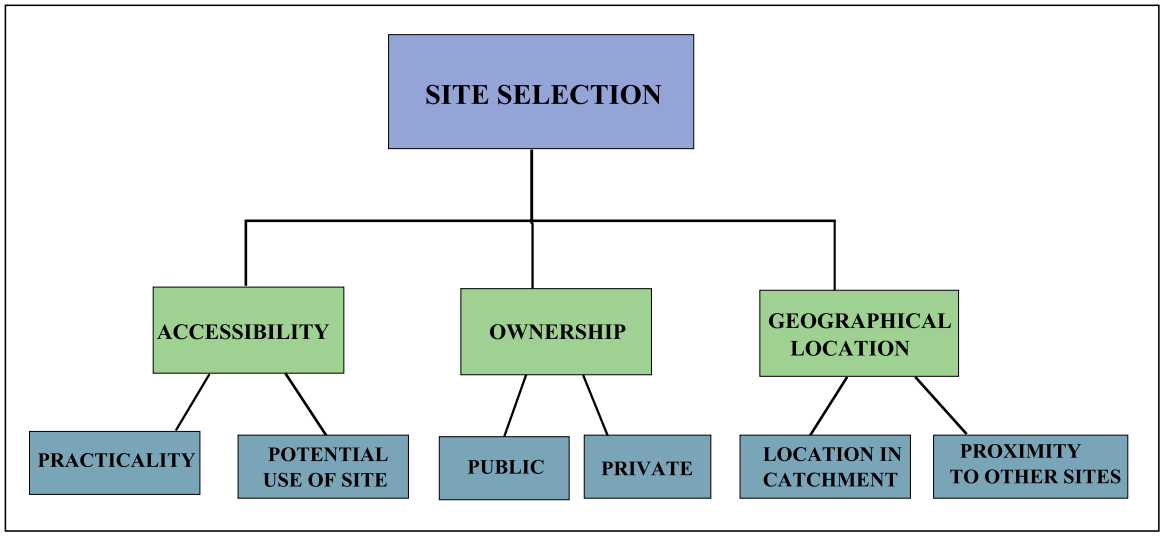

Figure 14 Factors observed to be influencing site location

Riparian restoration sites were observed to be either on public or private land or on a land co-owned by both entities. The majority of the public land was administered by Selwyn District Council. It was considered in the analysis whether the establishment of more sites on public land than private was purely coincidental. Many key informants suggested various reasons for this divergence in ownership of restoration sites. For example, some key informants expressed that initiating work in a private land was complex. This complexity could perhaps be related to the difficulty associated with convincing landowners to adopt certain restoration work, for

example putting up stock-proof fencing. The Hastings restoration site is an example of negotiations to convince the landowner to adopt restoration. On the other hand, private landowners expressed several factors for not considering restoration. These results imply that the preference of public land for restoration was to a degree intentional. It may be that public land was preferred for ease of management and other practical reasons.

Funding is another possibility for this difference in ownership of restoration sites. WET receives funding from various groups but the majority is from government funding sources. It is likely, as suggested by Clewell and Aronson (2006), that the use of government funding sources is related to the utilisation of public land for restoration work. Another possible hypothesis, to explain the preference of public land could be that there is a perception in the catchment community that WET would be more willing to do work on public land than private. This would support the fact that most of the groups that approached WET about conducting riparian restoration were interested in doing it on public land.

Accessibility was observed as a factor influencing site selection. This factor is closely linked to the ownership factor as well as the proximity factor. It was clear from the interviews that public sites have greater road access than private land. Therefore, combination of these two factors could be contributing to the selection of sites with these attributes. One of the reasons for undertaking riparian restoration was identified as developing demonstration sites to educate the public (Table 7). It was clear from the interviews that this attribute of the site made it more preferable. Accessibility is therefore a significant factor considered when choosing sites for demonstration.

The other significant factor that appeared as influencing the site location was the geographic location. The analysis showed clearly that the main reason behind the clustering of sites closer to the lake edge was the existence of springs in the lower catchment. There was one site observed as an anomaly in this distribution pattern. The Mitchell Road mudfish site was the only site located in the upper reaches of the catchment. A restoration consultant explained that some of the reasons for deciding on this site included the availability of moisture and fertile soil for planting. In addition, the influence of hydrological conditions on the adoption of such practices has been noted in other studies (Jansen et al., 1990).

It is known that a majority of the catchment lies within the dry plains of Canterbury and the lower catchment contains several springs and streams (Mason et al., 1996). In the mid part of the catchment, it has been observed that rivers such as Selwyn River flows only for few months an year while in the lower catchment it flows all year (Kelly et al., 2006). There are greater number of springs found around headwaters closer to the lake (Figure 4) (Williams,

2008). It is likely that in this study, the greater distribution of springs in the lower catchment provided more effective conditions for plantings. Furthermore, this could have resulted in more sites being closer to these springs. However, the upper catchment also contains many tributaries and springs (Figure 4). This makes one question why the riparian restoration had not spread to these upper reaches of the catchment and why it was concentrated only around the lower end. It is very likely that this is related to the informal network operating in the lower end of the catchment. These will be discussed in more detail in the following section.

There were few other possible reasons as to why there were more sites located in the lower catchment. One was that it could be related to the issue of land ownership. One key informant suggested that it is possible that the increase in riparian restoration sites closer to lake shores is related to the availability of more public land in that area. However, there are few riparian restoration sites on private land near the lake shores. Therefore, it is evident that availability of public land was not the main reason for sites being clustered near the lake. But it can be speculated that based on the information gained that there is a relationship between ownership and geographical location of the site.

With regard to geographical location, it was also noticed that sites were shown preference if they were in close proximity to other sites. It is possible that these sites were preferred to increase efficiency and practicality of conducting the riparian restoration work. For example, the analysis of interviews revealed that restoration consultants find it easier if restoration sites are closer to each other so that equipment and workers could be shared between sites. It is also possible that there was greater diffusion of information due to proximity. This is a significant factor and will be explored further in the following section.

In summary, three main factors, ownership; geographic location and accessibility, were evident to be influencing the site selection. Finding a site to conduct restoration work is among the first steps of riparian restoration initiatives of WET. Most sites were not selectively chosen but formed as a result of an opportunity provided to WET. In the formation of sites, public land was observed to be preferred to private land. Land which was easily accessible was also a preference. Lastly, the availability of springs in the lower catchment made it a more effective area to conduct plantings.

6.2 RIPARIAN RESTORATION AS AN INNOVATION

This study was focussed on gaining an insight into the diffusion of riparian restoration in the Lake Ellesmere catchment which consists largely of farming communities. It was argued that the diffusion of innovations theory could be applied to investigate this spread and gain an understanding of how landowners make the decision to consider riparian restoration. Previous studies have used similar approaches to investigate and understand how conservation decisions are made by local stakeholders (Atwell et al., 2009).

The most significant thing about an innovation is the characteristics of the innovation as perceived by potential adopters (Rogers, 2003). In this case, riparian restoration is the innovation whose characteristics were explored to understand the diffusion.

Previous diffusion studies done on conservation practices revealed that an innovation's relative advantage, compatibility, trialability, observability and complexity impacts the perception of a practice as well as the decision to adopt (Atwell et al., 2009; Jacobson et al., 2003; Padel, 2001). Some of these characteristics were apparent in WET's riparian restoration initiatives and had a significant influence in the decision making process of adopters.

The analysis revealed that there were several factors influencing the adoption of riparian restoration in the local communities of the lower catchment. They have been grouped into four themes but many of the factors interlink with each other (Table 8).

Table 8 Factors influencing potential adoption decisions

Community adoption of riparian restoration
Personal interest in conservation practices
Volunteer participation
Reinforcement through government agencies and local groups
Benefits from the practice

In this study, it was found that riparian restoration is perceived as a desirable practice if it has the potential to bring advantages to the potential adopter. The analysis provides examples where the personal benefits from getting involved in riparian restoration work contributed to an individual's perception of the practice. For example, the farmer at the Pakoau site decided to fence the site as he understood that he could obtain benefits from DOC for taking that action. Similarly, it may be possible that the farmer at Hastings Terrace who has been a hesitant partner, may have been convinced as ECan tried to make him aware that taking part

in restoration work could aid in meeting his resource consent requirements and similar regulatory duties. There are other studies that have indicated a farmer's hesitation to adopt some conservation practice may be due to them not perceiving potential benefits from the innovation (Kremer et al., 2001). Informants in this study mentioned that riparian restoration may aid in promoting farming as a greener practice. It can be speculated that the reason for this vision is related to the negative portrayal of farming in the media. A retired farmer stated that he thinks a lot of people are getting more interested in riparian restoration as a means to clear this negativity and bring farming into a positive arena once again. It is evident from this study that subjective perceptions of individuals about riparian restoration had a great influence in the adoption decision. Parnell (2006) similarly restates this and confirms that landowner's adoption of conservation practice is dependent on their expectation that this practice would achieve better goals.

In addition, Atwell et al. (2009) state that adoption of a conservation practice depends on the perceived subjective values. Similarly, it was found in this study that an individual's perception of riparian restoration influences adoption. These perceptions include those with regard to aesthetic values, cultural values and conservation values of the riparian restoration. This is exemplified in the case of the site at Selwyn Waikirikiri Delta. The site was mainly Ngāi Tahu land and they were keen to conduct riparian restoration at the site. It could be seen that the Ngāi Tahu considered riparian restoration as a way to enhance cultural values of the land and had visions to improve the area as a local mahinga kai. Similarly, the landowner at Knights Stream wanted to conduct riparian restoration as he saw that in the long term it would bring aesthetic values to his land. In addition, this study showed that a personal interest in the conservation issues may facilitate their decision to become more proactive. For example, as stated in the results, informants keen on riparian restoration were hasty in deciding to conduct plantings on their land. They understood the benefits of riparian restoration and hence, were willing to participate in carrying out the practice. Clewell and Aronson (2006) discusses that an individual's attachment to land whether it be environmental, spiritual or cultural, could be a motivation to conduct restoration work. Some of the earliest restoration attempts were led by people who had this attachment to land and wanted to take this to the next level to show action for their thoughts and views (Clewell & Aronson, 2006). A fishermen in the Ellesmere catchment stated that it was his attachment to the land that led him to finally act and do some restoration on his land.

However, it is evident from the study that these perceived relative advantages alone do not influence the decision of an individual. Even though riparian restoration may seem as

desirable for an individual, many other variables were observed as influencing the consideration of adoption of this practice. This discrepancy between what is desired and what in reality is practical has been found in other studies as well (Atwell et al., 2009).

The discrepancy comes as a result of comparing the compatibility of riparian restoration with the ongoing practices, needs, values, experiences and lifestyle of an individual (Atwell et al., 2009; Pannell et al., 2006). From the analysis, it was clear that certain aspects of riparian restoration made it less a priority in an individual's existing practices whether it is farming or other work. It should be reiterated that riparian restoration is a practice that requires hard work and commitment. However, as a key informant pointed out farming alone is a full time job and requires as much commitment. Presently, riparian restoration is not a priority in their life and Rogers (2003) emphasises that the rate of adoption will be greater if the innovation is compatible with the current lifestyle of an individual. However, there are other reasons which make riparian restoration appear less compatible with the existing practices and lifestyle.

Many studies suggest that financial cost is a variable influencing the perception of the compatibility of an innovation (Atwell et al., 2009). High cost of conservation practices has been observed as a burden to farmers and often results in their non-adoption of a practice (Curtis & Robertson, 2003). Similarly, in this study cost was identified as a barrier to adoption of riparian restoration. The analysis brought to attention the financial costs associated with conducting riparian restoration work, for example, fencing and spraying. These factors hindered individuals from conducting riparian restoration although there was approval for restoration work. In fact, analysis from background to the sites on private land reveals that the funding and manpower provided by WET did aid the landowner's decision to adopt and continue the practice. Wejnert (2002) also states costs can be in the form of indirect costs. This was exemplified in our study where it was observed that an indirect cost of riparian restoration could be the loss of valuable grazing land. The time commitment to riparian restoration was also observed as an obstacle for adoption. It can be argued that if the time dedicated to riparian restoration is compatible with the existing time commitments of a farmer then the consideration of the practice would be easier.

Long term maintenance of the plantings is a requirement for riparian restoration. Key informants reiterated this several times in the interviews. The overall complexity of a practice was observed to be increasing if the practice is perceived as involving greater management of the land (Pannell et al., 2006). The background to the sites (Appendix 2) reveals that native plantings needed continual maintenance (which includes replacement planting) until they are observed to be self supporting. The maintenance work for the sites in this study is mostly

being carried out by WET and SDC. However, it could be argued that this complexity of riparian restoration acts as a barrier for individuals to conduct restoration work on their land. One retired farmer indicated that his worry was that whether he could provide the time to continue management of the plantings once WET completed their work on the site.

It is possible that these obstacles could be aided by an innovation's degree of trialability and observability. Trialing could decrease these uncertainties and risks associated with an innovation (Atwell et al., 2009; Pannell et al., 2006). In this study, it was not observed that riparian restoration was used on a trial basis. Atwell et al. (2009) indicates the difficulty of adopting conservation practices (for example, planting of perennial vegetation) on a trial basis because of the difficulty of high implementation costs of establishing such a practice. This may have been the reason why none of the sites in this study had conducted riparian restoration as a trial.

Observability is the last characteristic which needs to be explored. Studies have indicated that observability of an innovation is significant to how an innovation is perceived (Rogers, 2003). Observability can either refer to the degree to which an innovation can be demonstrated. However, it can also refer to observed positive outcomes from innovation. Outcomes of conservation practices such as riparian restoration cannot be seen until some years later (Pannell et al., 2006). The absence of positive response does have a negative impact on the overall diffusion process. For example, key informants identified improving water quality was an objective of riparian restoration practice (Table 7). At the Silverstream site, the first group who conducted the restoration work was working towards this objective. However, there was no indication that water quality in that area was improving. This discouraged the group and it was one of the reasons they decided to discontinue their work. It has been suggested that this rejection does come around in the absence of lack of connection between the action and observable outcome (Pannell et al., 2006). Similarly, it is evident similarly in this study that differences in individual's perception of outcomes and the reality acted as an impediment to adoption of riparian restoration.

Demonstration plots encourage an individual to make a judgement about an innovation (Tumbo et al., 2010). Pannell et al. (2006) suggest that observability of a practice enables 'over the fence' learning by landowners. It is evident that much of the riparian restoration in this study was conducted with the objective of developing the sites as demonstration areas (Table 7). Such examples include sites like Days Road Drain, Knights Stream and Osterholts Road. It was also found from this study that the visibility of riparian restoration initiatives has in the past motivated other individuals to conduct similar work. For example, key informants

mentioned that Harts Creek Reserve is proving to be a good example to locals and many have inquired about the work being done there.

In summary, riparian restoration has relative advantages such as the benefits to individuals in facilitating regulatory conditions. However, restoration has been observed as a lengthy process and hence for individuals especially farmers it is hard to fit this practice in their lifestyles. It is perceived that adopting the practice would require time and commitment which are often variables that cannot be spared. Riparian restoration becomes a complexity for this similar reason and hence this is another barrier for diffusion of the practice. The study also indicated that observability of riparian restoration has at times facilitated locals' awareness of the practice and passed along important information. Subjective perceptions of individuals influence the decision to adopt most of the time.

6.3 THE SPREAD OF RIPARIAN RESTORATION IN THE CATCHMENT

Information on riparian restoration appears to diffuse in the catchment mostly through informal communication pathways. The analysis of the interviews indicates that the riparian restoration work was initiated by different groups through various pathways operating in an informal social network. Figure 15 provides a conceptual diagram of the informal social network that seems to be established in the Ellesmere catchment. Five main groups were observed as belonging to this network. It was also identified that within the network there are key actors and feedback loops diffusing the information. The connections between the key actors and these groups seem to be providing an input in to riparian restoration in the catchment.

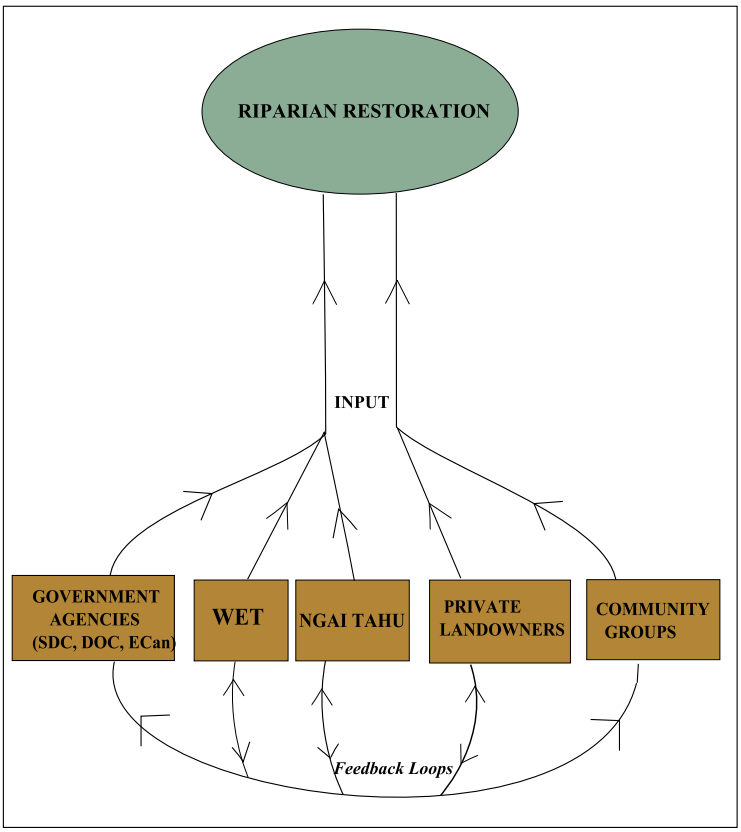

Figure 15 Conceptual diagram describing the riparian restoration diffusion pathways (with the key actors)

The significance of informal networks in diffusing information about an innovation has been recognised in many other studies (Atwell et al., 2009; Curtis & De Lacy, 1996; Thomson & Pepperdine, 2003). Interpersonal communication has proven to be an effective way of diffusion especially in rural communities (Atwell et al., 2009). Similarly, it was evident in this study the significance of existing partnerships and social connections within the community. Many of the informants expressed the importance of partnerships with the key people within the informal social network. All these groups appear to be operating on this basis and information is diffused along these already established pathways. There appear to be certain information sources in the catchment which are feeding into each other and communicating the information to the right people. As Feder (2006) suggests the pattern of information flow on riparian restoration is connected to this informal network and the contacts between individuals and groups in this network. There appears to be horizontal links between the local groups and organisations in the catchment and vertical links between different agencies. These links have been identified to be crucial for an effective social network (Pretty & Smith, 2004).

There are a range of actors from different backgrounds seen to be operating in the informal network. Individuals were from the larger regulatory bodies, cultural groups to smaller local community groups. The capability and capacity of these groups may vary but there appears to be a good collaborative effort in action. It has been suggested that a degree of hetrophily is required for diffusion of new information (Rogers, 2003). Therefore it is possible that the interaction of individuals in this network is a reflection of this. However, it could also be speculated that homophily still exists at the grass root level of the community. It has been suggested that communication is more effective if homophily exists (Rogers, 2003). The analysis did show that at times the initial information was communicated from farmer to farmer or through the local channels (for example, streamcare groups) before reaching the groups external to the local community (for example, SDC). Other times information trickles down from the authoritative groups to the local community.

It was evident in this study that community groups contribute greatly to the diffusion of riparian restoration. The analysis revealed that these groups had at times influenced the formation of sites. The Osterholts Road site is a good example as it was formed as a result of efforts of the Old Tai Tapu Road streamcare group. Furthermore, individuals in the community groups were observed to be delivering essential information to people who can act on it. For example, the Marshalls site was formed with the aid of the Leeston Residents Association. They helped the landowner, Mr. Marshall, to convey his concern to SDC. The effectiveness of such groups in contributing to successful biodiversity outcomes has been recognised in other studies as well (Pretty & Smith, 2004). For example, in Australia, the activities of landcare groups in rural communities working at catchment or sub-catchment level have been found to have increased awareness and the level of knowledge of land management issues, and influenced adoption of best management practices (Curtis & De Lacy, 1996). The activities of these groups range from awareness raising, hosting field days, erecting stock-proof fences and weed control. The community groups involved in this study have been described as conducting such similar activities. They have proven to be effective in diffusing information on restoration and also conducting restoration work independently.

Similarly, in this catchment the existence of streamcare groups facilitated many of the riparian restoration initiatives at sub-catchment level. Such streamcare groups consist of voluntary members from the local community usually with a keen interest in the restoration of waterways in vicinity of their properties. It was noted that these groups were among the more active voluntary groups in the community. Harts Creek Streamcare group were mentioned in almost all interviews with key informants. The existing level of respect for this group and

praises for their work in restoration of waterways was duly observable in these interviews. It is possible that these groups receive good support because the work is being done as a voluntary community effort. Efforts of such groups are getting more recognition and government agencies are promoting formation of such groups to get better involvement from locals in land management issues (Curtis & De Lacy, 1996; Pretty & Smith, 2004). It has also been stated that formation of local groups such as streamcare groups is evidence of the high social capital in a local community (Pretty & Smith, 2004). Subsequently, increases in social capital paves the way for effective resource management programs.

The significance of certain individuals or groups for diffusion of riparian restoration was evident from the analysis. Diffusion research discusses the role of change agents in accelerating the diffusion process and influencing the rate of adoption (Figure 10) (Lundblad, 2003; Rogers, 2003). It was observed that there were similar change agencies and change agents operating in this network. Government agencies were recognised as a prominent group in the network. The contribution of SDC, ECan and DOC to riparian restoration work is clearly described in the analysis. Change agents have been found to be initiators of change and good mediators (Lundblad, 2003). It appears from this study that there is one individual from each of the mentioned government agencies which fits into the role of a change agent. However, it should be noted that these change agents differed from change agents in the agricultural disciplines advocating and promoting new practices (Rogers, 2003). It was clear that at many of the riparian restoration sites, these change agents had more of a supportive role rather than a leading role and has been shown to facilitate restoration work within their capacity. For example, at sites such as Leeston Creek and Knights Stream, the change agents acted as facilitators and aided to establish restoration programs. Similarly, the analysis also revealed that reinforcement from change agents is one factor influencing potential adoption in this catchment (Table 8). Change agents were observed as being supportive and providing encouragement to the locals during the formation and establishment of the sites. It appears this formed a relationship based on trust and respect between the locals and change agents. This relationship could possibly have accelerated the diffusion process for some sites. Pretty and Smith (2004) emphasise that such bonds between groups can lead to social cohesion and create capacity for greater collaborative work.

It is also evident that external agencies other than government agencies acted as change agents in the diffusion process. Ngāi Tahu has a special role in the diffusion of riparian restoration as their focus has a greater cultural component than the other groups. Te Waihora/Lake Ellesmere is a major source of mahinga kai and it was apparent that Ngāi Tahu

was keen to restore these values into the catchment. WET appeared to have the role of both a coordinator and facilitator in diffusion of riparian restoration. It appears from interviews with key informants that initially locals were not aware of the initiatives of WET, but this has been changing recently. It is also evident that the partnerships WET has with other groups enabled them to be aware of opportunities for potential sites. It is evident that these relationships are very important for WET to continue their restoration initiatives. For example, a restoration consultant emphasised that the main reason for choosing a site in the upper reaches of the catchment was so that more contacts can be made. It was thought this provided an opportunity for WET to get more involved in those areas and thus as a start the establishment of new partnerships.

Change agents are also observed as advocators of views of a change agency (Rogers, 2003). This can be exemplified with the case of Hastings Terrace site (Appendix 2). The government agency initially contacted the landowner because of a breach in relation to the cattle crossing the stream. The change agent was requested to get involved in these discussions and advocate for the development of a temporary bridge to avoid this issue. The mediation of the change agent finally resulted in convincing the landowner to carry out this work and furthermore led to the landowner being convinced of initiating restoration work on his property.

Although change agents external to a social system have a significant role in the diffusion of innovations theory, this does not mean that top down initiatives work better in rural communities (Butkevičienė, 2009). Butkevičienė (2009) argues that bottom-up initiatives work better in rural communities because they enable individuals to deal with the issues at a community level. However, the author states that these initiatives do benefit from the work of external agents as they can facilitate the process. It can be perceived that this is the preferred way of action for the local communities in the lower lake catchment. It was known from the analysis that volunteer participation for riparian restoration is preferred to being pressured into adopting a practice (Table 8). It can be stated that the Hastings Terrace site was an exception to how the other sites were formed. It is exemplified from this case that adoption is more complex and lengthy when the initiative is not initially considered by the individual.

The other significant actors in a diffusion process are opinion leaders (Rogers, 2003). It appears from the analysis that there are few individuals in the informal network who have characteristics of opinion leaders. Opinion leaders could be any local from within the community who are well respected and have a degree of knowledge, expertise and links within and outside the community (Lundblad, 2003; Valente & Davis, 1999). Opinion leaders in this network have been found to be locals with a long family history in the catchment.

It was evident from this study that opinion leaders were influential in the diffusion of riparian restoration. Many of the times, these opinion leaders belonged to more than one group in the social network. For example, one opinion leader was found to be involved in WET and a streamcare group while doing independent restoration as well. Opinion leader's contacts and relationships with other members within and external to the community have aided in spreading knowledge on riparian restoration and have at times motivated others to do it. It was observed that information was passed through these existing partnerships and relationships. An evidence of this is that many of the riparian restoration sites were formed after discussion with an opinion leader. Pakoau site and Ogg Drain sites are good examples of this.

The role of private landowners was not explored to a great length in this study. That was one of the limitations of this study. However, it was found that these individuals had acted in their own capacity to spread riparian restoration. Most of the times, these individuals have social connections with community groups. Their attempt to influence other locals to adopt riparian restoration is also duly noted in this study. The greater role of locals in biodiversity conservation is strongly emphasised in many studies (Curtis & Robertson, 2003; Pretty & Smith, 2004). It has also been found that trust facilitates cooperation and as a result individuals are more confidence in adopting in collective decisions (Pretty & Smith, 2004). Similarly, in this study many informants strongly stated that referral from a trusted individual is needed to get work done in local communities. Another key informant stated that individuals better accept riparian restoration if they are made aware of other locals in same community conducting riparian restoration work. This is evidence that social capital is very important for diffusion of riparian restoration.

Diffusion studies have emphasised the influence of geographical proximity in diffusion and adoption of an innovation (Brown, 2009; Wejnert, 2002). Similarly, in this study proximity appear to have influenced the spread of riparian restoration. Some of the riparian restoration sites were formed as a result of them being in close distance to other sites. Informants also stated that they knew about riparian restoration as they saw and heard about restoration being conducted close to their lands. In addition, proximity to other sites has been one of the reasons for conducting restoration, but these have been mainly for efficiency and practical reasons. However, there is evidence that distance can impact individual's personal interaction and thus affect communication pathways (Wejnert, 2002). This may contribute to WET's riparian restoration sites being found to be concentrated in the lower catchment rather than throughout the catchment. It is likely that the influence of the informal network diminishes in the upper

reaches of the catchment. It may be, as suggested by a WET staff, that at the upper catchment there are fewer contacts of WET. The lack of these connections would make it less possible to get through to the existing network. Therefore, this could result in preference of riparian restorations in the lower catchment where there is greater connection of local groups and external agencies.

In summary, it is evident from the analysis that riparian restoration spread in the lower catchment through an established informal network. Five groups, government agencies, WET, Ngāi Tahu, community groups and private landowners were identified as being significant contributors to the diffusion of riparian restoration practice. It appears that diffusion pathways are interlinked and feed into each other. The role of change agents and opinion leaders as influential actors in diffusion process is evident in this study. Finally, it can be concluded that Waihora Ellesmere Trust receives information about the desire to conduct riparian restoration mainly through these opinion leaders and change agents.

6.4 UTILISATION OF DIFFUSION FRAMEWORK TO THE SPREAD OF RIPARIAN RESTORATION

It has been questioned whether the classic diffusion model can be applied for conservation innovations (Atwell et al., 2009; Nowak, 1982). It is evident in the literature that diffusion studies have mainly focussed on innovations with financial gain and its adoption. Research on diffusion of conservation practices could have been possibly given less attention as its outcomes are not often seen in the long term and hence the conservation value not observed. Conservation practices are also flawed with uncertainty and risk (Atwell et al., 2009). Therefore, it is important to explore if the diffusion framework can be utilised to explain the spread of riparian restoration, an innovation with no direct financial gains.

In this study, the data compiled was analysed to explore how riparian restoration initiatives of WET diffused in the catchment. It was identified that an innovation, time, communication channels and a social system will be present in almost all diffusion research or programmes whether it is spontaneous or planned (Rogers, 2003).

The first aspect of note is that the spread of riparian restoration happened in a random manner even though restoration initiatives were planned. The diffusion theory was useful in identifying the characteristics of riparian restoration that was observed to influence its adoption. Riparian restoration's relative advantage with some degree of observability appears to be positively contributing to the spread and adoption. However, riparian restoration also

appeared to be less compatible with the current practices of locals and this is enhanced by the complexity in maintaining the plantings. Many of these characteristics have been shown to influence the adoption of similar conservation practices (Jacobson et al., 2003; Padel, 2001).

Effective communication pathways and a connected social system are required for the diffusion of an innovation (Rogers, 2003). This would be effective in ensuring enhancement of local knowledge on riparian restoration and creating greater social cohesion that would lead to effective cooperation (Pretty & Smith, 2004; Tumbo et al., 2010). There is evidence that an existing informal network was influential in the spread of WET's riparian restoration initiatives. It also was evident that certain individuals in this network had a greater key role than others but all of them were observed to be contributing to the diffusion of the restoration. The network depended on interpersonal communications between these actors. There was horizontal communication at the local level as well as vertical communication between external groups and the locals. However, diffusion is not as simple as just communication through this informal network. Diffusion and adoption of the practice was influenced by the high maintenance of riparian restoration efforts. The financial cost of restoration work was identified as adding to this barrier. However, the non-profitability of riparian restoration was not identified as being an issue, unlike in other conservation studies (Guerin & Guerin, 1994).

There were also other variables that were not apparent in other conservation related diffusion studies. These factors do not fit well into the diffusion framework but has a degree of significance in the spread of riparian restoration. Some of the factors include the issue of ownership and effect of geographic location of site to the diffusion process. These factors are concerned with selection of sites and the diffusion of innovations theory does not provide an explanation for such localised issues. Atwell et al. (2009) suggest that a proper understanding of the sociological, ecological and political contexts is crucial to gain an understanding to the diffusion and adoption process of a conservation practice. Therefore, it can be concluded that diffusion of innovations theory is useful in providing an understanding of the overall spread of WET's riparian restoration initiatives.

7 CONCLUSION

Riparian restoration is beneficial to the values of the Lake Ellesmere and its catchment. This has been recognised in CWMS and the Te Waihora/Living Lakes Symposium. This dissertation was developed with the targets of the CWMS in mind and it was anticipated that the results of this study would improve our understanding of the spread of riparian restoration in the catchment. The focus was on the WET's riparian restoration initiatives in the catchment and the aim was to use diffusion of innovations theory to understand the spread of these restoration works.

WET's riparian restoration initiatives have spread rapidly in the last two years and most of the work has been conducted in parts of the lower catchment. Initially, the spread of WET's restoration initiatives was slow and only resulted in the formation of a few sites in the early years between 2004 and 2006. However, during this time WET established partnerships between individuals of the government agencies working in the catchment, Ngāi Tahu and the local community groups. This facilitated their prominence in the local communities. In the last couple of years, riparian restoration work of WET has received greater recognition and this appears to have resulted in the formation of the more recent sites. Over the years, an informal network has become established in the local communities of the lower catchment. Partnerships and connections in this network influenced the communication of information of potential restoration sites and the knowledge on riparian restoration. The importance of the social capital in the communities of lower catchment in influencing the diffusion of riparian restoration is also evident from this study. The spatial aspect of diffusion was also recognised as influencing the spread of riparian restoration. It is likely that the informal network is only operational at the lower catchment and there is a lack of connection to the upper catchment. This would explain for the lack of riparian restoration sites in the upper parts of the catchment.

The adoption of riparian restoration was dependent on several factors. The scope of this dissertation and time constraints did not allow for a complete exploration of these factors. However, it could be seen that similar with other conservation studies, characteristics of riparian restoration such as relative advantage, compatibility, observability and complexity influences the rate of adoption. It can be established from this study that the subjective perceptions of individuals do contribute greatly to the adoption of riparian restoration.

In summary, the biggest obstacle noted for adoption of riparian restoration was the financial cost. It was evident that availability of funding was a key reason that WET was approached to

conduct riparian restoration. The funding component is also related to the increase in number of riparian restoration sites on public land than private land. The financial limitation was also identified as reasons why farmers are reluctant to do independent riparian restoration work. Funding capacity together with the cooperation in the informal network appeared to be the greatest elements impacting the spread of riparian restoration. The connectedness of locals at the grassroots level was not explored to a great length in this study. However, there is evidence that these connections act as the base for communication in these rural communities. The existence of change agents and opinion leaders are also a key to the spread of riparian restoration. These key actors can potentially influence the action of other locals in the communities.

In conclusion, WET's riparian restoration spread mostly in the lower catchment through the existing informal network and adoption was greatly influenced by the funding capability. Future riparian restoration programmes in Lake Ellesmere catchment should consider the importance of these informal networks and the different factors influencing the rate of adoption.

7.1 FUTURE RESEARCH

This dissertation was focussed on only the riparian restoration initiatives of WET. It is anticipated that this study would be used as a pilot study and the key findings of this study would be further explored in future research.

It is recommended that future studies explore the social, ecological, cultural and political contexts of the diffusion of riparian restoration. Aspects of these contexts were apparent in this study and it is important any future research is aware of the significance of these factors in relation to the diffusion.

Future research can also concentrate on the overall riparian restoration initiatives in the lake catchment including those of WET. This would provide a broader picture of the diffusion of riparian restoration and a greater understanding of influencing factors.

Similar studies could be conducted in other catchment areas. It would be interesting to see if there are any similarities or differences when such a diffusion study is conducted in other settings. It can be hypothesised that the presence of Lake Ellesmere in this catchment may have influenced some of the factors discussed in this study.

It is very important that the adoption behaviour of local individuals especially farmers with regard to riparian restoration be studied separately. This topic is a complex issue but it needs to be explored so that further riparian restoration programmes could be developed by taking into account the important factors influencing adoption. In addition, these riparian restoration programmes can aim to alleviate the observed barriers for adoption.

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APPENDICES

APPENDIX 1: MAP SHOWING THE LOCATION OF WET'S RIPARIAN RESTORATION SITES

APPENDIX 2 : BACKGROUND TO THE WET'S RIPARIAN RESTORATION SITES

R1 - AHURIRI LAGOON

This area is a natural retention basin on the Halswell River off SH75. The initial idea for this site arose from discussions between members at the early stages of Waihora Ellesmere Trust's (WET) establishment. WET members, Collin Arps and Julie May, were keen to do some restoration work in this area. Their vision was that riparian restoration at the site could improve nutrient filtering functions of the lagoon and hence had potential to become a proper wetland area in the long term. However, Environment Canterbury (ECan) advised WET to keep the site as a drain. Therefore, the initial project did not happen as aspired.

However, a small planting day was held there in early 2004. The actual planting was not in the lagoon, but was done at a small stream near the Ahuriri Lagoon. This stream runs right on to the road and the planting done in 2004 is still evident there. The planting was done in conjunction with a seminar held at Lincoln University. After the seminar, a busload of participants went out to the site and planted some native plants. The site location was initially a grazing area but has since then retired from grazing.

There have been further discussions about the project since 2004. In 2006, a project proposal was prepared. It was recognised that the site was a potential project for community restoration efforts in collaboration with ECan, Te Ara Kakariki and Railway Trust. In 2008, ECan applied for a resource consent to build a swale and take water from the river to rehydrate the area. However, due to a mistake with the consent, it did not go ahead. Presently, the project is on hold, but there is potential for riparian restoration and potential to work with ECan to establish the hydrology.

R2- BOGGY CREEK

Boggy Creek is a classified drain and a major stream which at the lower end runs adjacent to Colletts Road in Leeston. The riparian restoration was done at a section of Boggy Creek that runs along the side of a Fish and Game reserve on the western edges of Lake Ellesmere. This reserve land is near the lower end of the stream.

In the past, this site has had trouble with the stock breaking through the old fencing and crossing the waterways. Fish and Game were keen to get the fences improved and protect the stream. Fish and Game made the initial contact with WET. A personal communication was made with Stephen Brailsford, WET's riparian consultant. Fish and Game approached him on advice about restoration at the site. Stephen made some suggestions and that is how the project started.

It was a council drain and therefore SDC was involved. The adjoining neighbours (Inwoods) were interested in the project too. A partnership was formed between Fish and Game, WET, SDC and the Inwoods. ECan and Ngai Tahu also supported the project.

There has been some restoration work done here previously. The first planting of the riparian restoration programme took place in July, 2010. The Inwoods were helpful and moved the fence line back to accommodate the planting. There were 2,482 native plants planted at the site. This included *Carex secta* and a mixture of other native plants. Funding was provided through various sources such as the SMF. There is maintenance needed for the next 2-3 years. SDC and Fish and Game have agreed to provide the funding for this ongoing maintenance. This project is the outcome of the collaborative efforts of Fish and Game, WET, SDC and the Inwoods.

GREEN FOOTPRINT PROJECTS

Green Footprint Project is a partnership formed between Youth Hostel Association (YHA) and Selwyn District Council (SDC). The original Memorandum of Understanding was between YHA, SDC and Landcare Research. However, WET has been involved in the project from the beginning and Landcare Research was only a partner in the early years.

The Green Footprint's vision is to create a 2.5 km corridor of native plantings extending from Chamberlains Ford to Coes Ford which would also include a walking track. Their objective is to establish native plant communities along the lower reaches of Selwyn River. In achieving their vision, they aim to enhance indigenous biodiversity, create awareness among local community, educate participants and facilitate sharing of information and knowledge. It is also envisaged that in the long term the Green Footprint sites would become great demonstration site to create awareness and educate people about local biodiversity, native vegetation and riparian restoration. Presently, there is a management reserve committee under SDC who is responsible for the management of the reserves.

The project was initiated by the Youth Hostel Association. They were interested in doing some voluntary work that can contribute to biodiversity restoration. Therefore, this project was the outcome of brainstorming between YHA and the other partners. The role of WET in the Green Footprint partnership is to provide technical assistance to the native planting aspect of the project. WET also provides assistance in preparing the site for planting and the maintenance of the plants. Volunteers from YHA, WET Staff and SDC staff are involved in the planting days. YHA provides a great part of funding for the planting days. Selwyn District Council is responsible for the maintenance and provides the funds for this.

Riparian restoration is being done at the Coes Ford and Chamberlains Ford reserves. They both are active recreational sites with a river environment consisting of attractive vegetation. The sites are similar in most characteristics except for water quality. The water at Chamberlains Ford is considered to have highest water quality in Selwyn District, whereas the water at Coes Ford has been deteriorating over the years and is considered as having very poor water quality in terms of recreational use.

There has been annual planting at either one site or the other since 2004. There has been around seven years of planting in this project. WET was not involved in 2009.

R3- COES FORD

The Coes Ford riparian restoration project is part of the Green Footprint projects. The first plantings of the project were done at this site. The first planting was done in 2005. It is speculated that the main reasons for choosing this site was because it was an easily accessible public land in addition to being a recreational reserve. The site had potential for riparian restoration and it was envisioned that in the long term this could improve the water quality and the biodiversity of this area. There were planting days held in 2005, 2006 and 2007 at this site. WET coordinates the planting.

There has been great progress of this riparian restoration initiative. Currently, the Coes Ford planting areas are well established and the vegetation is looking healthy. There is a range of mature native plants visible at the site. This site is one of the success stories of riparian restoration in the Ellesmere catchment.

R4- CHAMBERLAINS FORD

The Chamberlains Ford riparian restoration project is part of the Green Footprint projects. This was the second site chosen for this riparian restoration. This site was chosen because it was similar in characteristics to Coes Ford and the vision behind the main project was to create a corridor between the two reserves.

The first planting at this site was done in September, 2008. The Chamberlains Ford reserve was full of willows before the start of this project. There was a lot of site preparation work done here which included removing the willows, black berry, ivy and rest of the weedy plants. The area was also sprayed and fenced.

There has been planting done at the site annually since 2008. Every year, around 1000 native plants are planted by volunteers and members of the partner organisations. Recently, there has also been more local involvement. Most of the members of the reserve management committee are locals and they have also been actively involved in the planting days. Neighbours from across the fords also join in and has done some work in the recent years.

R5- DAYS ROAD DRAIN

This is a drain owned by SDC adjacent to Days Road. This site was chosen as a demonstration site to show how native vegetation can be used to support sustainable drain management in addition to improving biodiversity values. The site was also an ideal location as the banks provide a good slope suitable for planting with Carex secta.

There have been ongoing issues in riparian restoration work in the drains in Selwyn District. The council is responsible for the maintenance of the drainage network. And the council's drainage personnel have had issues with planting of native vegetations along the drain and have at times removed them. They have been removed because they prevent the staff for easily accessing the drains for maintenance and also sometimes vegetation may hinder water from draining at flood times. WET held discussions with the drainage personnel. WET's restoration consultant (Stephen Brailsford) had the vision that riparian restoration work would prevent weed growth in the drains and thus in the long term vegetation removal would not be necessary. Eventually, the drainage personnel came on board with the idea and they were keen to develop a demonstration site.

The drainage personnel suggested this particular site. The site was selected because it was an ideal location. The banks provided a good slope suitable for planting with *Carex secta*. The site was easily accessible to the public and visible to locals. Also, the site was in proximity to Lincoln Dairy Farm where the contractor was doing similar restoration work and hence made the work more efficient.

There was a partnership formed between SDC, WET and ECan. The first planting was done by a contractor in November 2009. There were 383 plants planted which included a range of native shrubs and native trees. The planting was done along the eastern terrace of the drain. WET did the planting and is taking care of the maintenance. It is an ongoing project. SDC will contribute to the future maintenance of the plants.

This site was chosen as a demonstration site to show how native vegetation can be used to support sustainable drain. It is envisioned that the native vegetation will grow vigorously and provide shade from stream edge that would eventually prevent weed growth. This would reduce the need for mechanical removal of weed in the drain. Also, the growth of the plants would allow good passage of flood waters. The idea was for this site to become a sort of a research site.

R6 - DONALD'S / TAUMUTU

The restoration work is being done along the banks of the Waikekewai Stream at Taumutu in the sections that flow through a private landowner, Donald's, property. The stream is adjacent to the Taumutu Marae.

The site was seen as a potential area for riparian restoration work by a WET trustee, Clem Smith. He did a lot of riparian restoration work on his own property, which was just across the road from Donald's property. He saw that there was this piece of vacant land which Donald was not using and thought that it could be put to good use by planting native vegetation. Clem Smith suggested this and discussed the idea with Donald and got him interested. Then Donald was introduced to WET and a partnership was formed between the two. Another WET Trustee thought this site was a good opportunity to bring together planners from both Selwyn and Christchurch City together with Lincoln University students to discuss on issues related to the Lake. It was also an opportunity to show WET's commitment to address streams of considerable importance to Maori.

Donald signed an agreement guaranteeing access to the site and ensured that stock would be excluded. This agreement was further enforced by the erection of the stock proof fence.

The initial planting was done by a WET contractor and it was a small planting of 140 *Carex secta*. The second planting was done as part of a field trip of a joint planning conference between New Zealand Planning Institute and Planning Institute of Australia. A group of 15 planners together with volunteers planted 85 *Carex secta* along a section of the stream. The third planting was done by a contractor and 1,250 native plants were planted along the stream bank. This was undertaken in September, 2010. WET was involved in all of the planting sessions. WET is also undertaking the maintenance of the site. It is hoped that further planting days will be held in the future.

R7 & 8 - HASTING TERRACE, STAGE 1 AND STAGE 2

There has been riparian restoration work carried out at two sections of Hastings Terrace. The first stage of planting was done on land 60% owned by Stuart Hastings and the rest owned by SDC/Crown. The land ownership has been complicated by the Selwyn River/Waikirikiri changing course several years ago.

There is relevant history as to how Hastings Terrace was selected as a potential site. Environment Canterbury (ECan) made the contact with Stuart Hastings about 5 years ago regarding a breach over Selwyn River because the Hastings' cows were going through the river. However, it was impractical to build a bridge across the Selwyn River as it was wide. There was discussion between the Hastings and the ECan regulatory staff about resolving this issue but it did not result in a practical solution. David Hewson (currently, Senior Resource Care Co-ordinator at ECan) personally approached the Hastings and started discussions about a temporary bridge. They also discussed ways that ECan could assist with this bridge and provide help through the resource consent process. These discussions did eventually result in a positive outcome and a temporary solution was produced for the issue. These discussions also made way for a relationship to be built between ECan and Hastings. ECan aided Hastings in the co-ordination of the development of the temporary bridge by helping everyone involved get on the same page.

David Hewson had always been interested in the enhancement of waterways. He saw this area as a potential site for riparian restoration. The area being in private land does make it somewhat difficult for organisations to conduct plantings. However, there was an established partnership with the Hastings which made this area so suitable.

David Hewson made the first contact with WET. It was known to ECan that WET might have possible funding for such work and hence approached them. Stuart Hewson together with Stephen Brailsford went out to the area and had a look at potential sites. Later on, Stuart Hasting also showed another site that was of concern to him (stage 2). WET got involved in this site as they saw an opportunity to do some work in the Silverstream sub-catchment. Silverstream has been identified as priority area for WET's riparian restoration programme as it was one of the most significant polluters of the lower Selwyn River. The landowner, Stuart Hastings was a hesitant partner in the beginning, but he is now more on board with the restoration idea than before.

The project was initiated in late 2009. The landowner cleared sections of the area of willows and other weeds and then fenced them with his own funding. WET carried out the first stage

of planting which was in June, 2010. There were 6,460 native plants planted. The second stage of planting was done in September, 2010 and there were 1,823 plants planted.

Different planting techniques were used at the two sites. Stage 1 site did not use plastic guards and the plants can be observed to be growing wildly at that site. Stage 2 used plastic guards and plants at the site looked to be growing well and in a systematic way. The maintenance of both sites is being undertaken by WET.

Left : Stage 2, Bottom: Stage 1

R9- KNIGHTS STREAM / PENDER'S

This stream feeds into the upper reaches of Halswell River. Riparian restoration was undertaken at a section of this stream. A private landowner, Vince Pender, owned land where this section was.

Environment Canterbury drainage personnel worked with the landowner in clearing willows out of the stream and rebattering of the stream banks was done in early in 2009. The ECan staff thought this was a potential good site to carry out riparian restoration work. They contacted WET and discussed about this possibility. WET took on this project as the landowner was keen to do this restoration work and because the site was situated on the boundary of Christchurch City Council and SDC. The banks of the stream were on separate districts. The restoration site was on the bank of the stream administered by Selwyn District.

WET did the pre-plant spraying and the planting plan. The land owner fenced the site. There is a planting agreement signed by WET and the land owner. There were 1,942 plants planted by a contractor. WET will carry on the maintenance for 2-3 years until the plants are established and self-supporting.

The landowner is keen for the continuance of this project as his long term plans are to build a property on this land and he thinks the native vegetation would bring a greater aesthetic look to the property.

R10- LEESTON CREEK

Leeston Creek is a spring-fed stream that rises northeast of Leeston Township on a private land near Killinchy. The creek runs through private farmland, the Leeston Township and follows few kilometres to the Tramway Reserve Road. Leeston Township is mainly a farming community and consists of many farmers and retired farmers.

The riparian restoration project is being done at the section of the creek that runs through the Leeston Township. Members of the Leeston Residents Association, (Brenda Alfeld, Rose Chamberlain and Jeff Quigley) contacted Waihora Ellesmere Trust in 2007. They had heard of the work done by WET and approached WET, initially at the Leeston A&P Show stall. They indicated that they were interested in restoring this section of the creek. WET had previously supported the residents association in some of their past projects. This creek connects up to the Tramway Reserve and there was already work being done over there. Therefore, WET was interested and saw this as an opportunity to further improve ecological conditions of this whole area.

To begin with, the community did some clean up of the creek as it was battered badly. Then in spring 2008, a small native planting was done at this site. This was followed by plantings in 2009 and 2010. All of them were very small plantings and the idea was to slowly get the community on board with the restoration project.

Initially, residents association provided some funds and other funding was provided from Honda Fund (ECan). The funding sources had differed over the years. There are plans to continue riparian restoration at this site. A major planting is going to be done in 2011.

R11- MARSHALL'S / BIRDLINGS BROOK

The site is on Birdlings Brook and on a private land owned by David Marshall. Birdling Brooks flows into Harts Creek.

David Marshall expressed his concern for this part of his land few years ago. He was concerned because this part of his land is at a corner (corner of Harmans Rd and High St, Leeston) and comes out to a main road that had a speed limit of 100km/h. This area is a popular route for many people walking from and into the Township. David Marshall thought it was dangerous for people walking along the sharp corner where there was so much traffic.

He was a member of the Harts Creek Streamcare group and he mentioned the site to the group through a discussion about some fencing around there. The Streamcare group expressed Marshall's concern to the Leeston Residents Association. They were keen to do some work around the area and Marshall was keen to have it done on his land. He wanted to allow people on his land so that the danger of going on the main road could be avoided. This was how the project initially started. WET and the SDC got involved through the discussion process about the site.

David Marshall fenced the site and agreed to let the community access this stretch of stream bank as a walking track. There has been an attractive walkway established to facilitate this. Selwyn District Council has drawn up a plan for the site. Leeston Association and the Lions Club (a small environment committee in Leeston) cleared the site and prepared it.

WET's involvement was in the planting process. They installed 600 native plants along a part of the stream. There is now signage at the site put up by SDC. This site came into being in 2010. This project is an example of the collaborative efforts of small community groups. SDC and WET provided the support they required and it could not have gone ahead without the approval of the landowner. His keen interest was what initiated the project.

R12- MITCHELLS ROAD MUDFISH

This site is on a public land administered by Selwyn District Council which is an unformed legal road. The area of this land is 2.7 hectares.

The restoration work is being done at a stream on this land. The site adjoins Mitchells Road (a paper road) and the Hororata River upstream of its confluence with Selwyn River. The area has a stand of willow over a backwash in a river and the water in the stream only flows for few days of the year. This site has special conservation significance because it is a habitat for the Canterbury mudfish. Department of Conservation has been monitoring mudfish at this site for some years now.

The site formed when the adjoining landowner bulldozed the willow trees and cleared the land to make way for grazing. This event occurred in August 2008 and it happened because the landowner thought this area was part of his land. DOC discovered the site in this state on one of their monitoring visits. DOC and ECan had discussions with SDC as it was part of their land. The SDC reserves supervisor, Mike Kwant, made the initial contact with WET. SDC were already working with WET in the Green Footprint and hence had an established relationship. SDC wrote a letter to WET stating that the unauthorised removal of willow provides an opportunity to achieve significance conservation gains. Therefore, it was mentioned that partnership with WET was integral to successfully implement a restoration project. DOC also held discussions with WET regarding the site. WET's contractor at that time (Stephen Brailsford) saw the area as an ideal site for a restoration project. The site has already been pre-prepared for planting, had deep fertile soils and in addition had high biodiversity values. This site was also in the upper catchment whereas all the other sites WET did restoration work were in the lower catchment.

There was a loose partnership formed between SDC, WET and DOC. ECan also supported the project by providing technical advice and part of the funding through EEF/HTF. SDC also involved the adjoining landowner (not the one initially involved in the accident) and he was willing to participate in the restoration works. There has been support from the landowner with regard to spraying weeds and mulching weeds.

WET applied for funding in 2008 and early 2009 and eventually got funding from various sources. Some of the funders include World Wide Fund for Nature (WWF), Community Conservation Fund (CCF) and Sustainable Management Fund (SMF) and Sustainable Farming Fund (SFF).

The first planting was done on 5 June 2009, World Environment Day. An engineering consulting company, GHD, approached SDC and were interested in finding a location to do planting on World Environment Day. Therefore, WET worked with GHD and SDC to get the planting underway. GHD paid for the plants and their staff assisted in the planting. There were 1,077 native plants planted in the first phase. The second planting was done in August 2009 and 4,764 plants were planted. There were also plantings done in 2010.

To date, there have been over 13,000 native plants planted at this site. However, there have been mortality and around 9000 plants are left to thrive. SDC has visions for the future of this site. Long term plans include changing the legal status of the land to suit conservation purposes. However, this can be a lengthy and time consuming process. Meanwhile, they are working with DOC in considering a conservation covenant for the site. The covenant can ensure the protection of the indigenous vegetation as well the habitat for Canterbury mudfish. SDC is also considering the usage of this site as a demonstration site to educate locals. The site is relatively accessible and is public land. It is also has potential to become an attractive picnic area. The site can be used to raise awareness for Canterbury mudfish as well as riparian restoration works. The main issue with opening such a site to the public is the daily maintenance of the site.

To summarise, the Mitchells Road mudfish project is a great example of what can be achieved in terms of riparian restoration as well as partnering with different organisations.

R13- OGG DRAIN

Ogg Drain is part of a classified drainage network that flows into the Halswell River and restoration was undertaken on a section of this drain. It is on a private lifestyle block owned by R Ford on Rhodes Road.

The landowner approached the OTTR Streamcare group about doing some restoration work on his land. Stephen Brailsford brought WET into the idea. WET had some funding available and hence a partnership was formed. There has been a planting of 1,560 native plants undertaken in 2010.

R14- OSTERHOLTS ROAD / OLD TAI TAPU ROAD (OTTR)

The riparian restoration work is being done at a section of Halswell River. This project is the idea of the Old Tai Tapu Road (OTTR) Streamcare group. This group was formed in late 2009 by local landowners led by Stephen Brailsford and his wife. The idea behind the group was to do some work to enhance the river ecosystem and increase biodiversity values. The group was interested in a 8km section of the Halswell Road, which is mostly public land. Most of the landowners owned lifestyle blocks in the proximity of that area.

WET was involved in the OTTR Streamcare group since its formation. Stephen Brailsford, the person leading the group, is also a WET Trustee and this was how the partnership was formed. WET provided the required funding as well as some of the labour. Community Max Program (a work experience programme run in collaboration with Ngai Tahu which involves Maori youth that were referred from courts) and ECan river engineers aided in the preparation of the site by clearing and poisoning the willows.

The first planting was carried out in 23rd May, 2010. There was a community planting day held that attracted around 60 community members. Around 1000 native plants were planted by members of the community on that day. There was another planting done in spring 2010 which was mostly carried out by the contractors. By the end of 2010, there have been 2,460 native plants planted in the banks of the river. The plants are booming but would need maintenance for their continued growth. It is hoped that WET can undertake the maintenance.

There are environmental as well as social benefits that can be acquired from this project. This project brings together members of the community of different ages and has potential to increase cohesion in the society. It is also an educational effort as the site is visible to many locals and this can raise awareness among them.

R15- PAKOAU STREAM

This site is part of a large area of DOC land that is leased for grazing. The land is at the Lake Margin and important habitat for many native flora and fauna. Presently, the site has become a jungle of willow, gorse and other invasive weeds.

The adjoining land belongs to Ngai Tahu and that site is of significance to them because of the proximity to the Lake Shores and closeness to Taumutu. The Taumutu runanga has control over that land.

Department of Conservation and Ngai Tahu were interested in doing some ecological restoration work at this site. Ngai Tahu has been provided funds by DOC for the enhancement of longfin eel habitat. Both DOC and Ngai Tahu personally contacted the WET restoration consultant, Stephen Brailsford. Together, they all made a trip to the site and Stephen suggested that this site can be used for riparian restoration as well as aid in improving longfin eel habitat. Therefore, a partnership was formed between the three, DOC, Ngai Tahu and WET.

Most of the site preparation was done by Ngai Tahu. Stephen helped in pulling apart the gorse bushes and parts of the weed jungle. The site had to be pulled apart section by section as it had become a thick jungle. The planting to date has been done over 2 years in 3 stages.

In 2009, WET together with the Community Max Program did the first planting. It was done at a small section of the land. In the restoration process of Stage 1, the lessee (the farmer) erected a stock proof fence and thus received a rent holiday from DOC by doing this.

The second and third stages opened more parts of the site. There was planting done at both stages. To date, there have been 2,837 native plants planted at the site. WET continue to provide the planning expertise, plants, supervision of planting and maintenance of the site. Ngai Tahu together with WET would contribute to the cost of maintenance. WET seeks to maintain the partnership built with Ngai Tahu.

This site is good project where community groups can get involved with the planting days since it can be picked section by section. It is also a site that can be used as a demonstration site.

R16- SELWYN WAIKIRIKIRI DELTA/SPOIL BANK

This site is a spoil bank built with the sediments taken from when the Selwyn River mouth was cut several decades ago. The spoil bank is around 750m and infested with gorse and other weeds. Cows have been grazing this area for several years. The site is owned by Ngai Tahu and managed by Te Waihora Management Board.

Ngai Tahu was interested in clearing this area and restoring the natural habitat. They got the Community Max Program involved. There was 17 youth who worked at the site for five months. Stephen Brailsford worked as the technical supervisor for Ngai Tahu. The site was cleared, willow poisoned and the site fenced. A small planting of 600 native plants were planted in late 2009. Ngai Tahu was funding this work. After the program ended, Stephen Brailsford did a restoration plan for Ngai Tahu.

Stephen Brailsford made the initial contact with WET and a partnership was formed between WET and Ngai Tahu. There was a major planting done in spring, 2010 and 4,758 native species were planted. This site is unique as the area is a man-made structure which is elevated. This prevents inundation by salt water although it is at the edge of the Lake. There is opportunity to develop a plant community comprising of diverse vegetation that could not thrive in the neighbouring areas.

The site is a great site to be used as a demonstration site. The natural environment surrounding the site is excellent. There is a salt marsh over there and Totara podocarp forest. The surrounding area is mostly private land that is retired from grazing with some public land under Department of Conservation. The Selwyn huts are close by. There is a lot of recreational use occurring there. Ngai Tahu allows public access and the area is a popular destination for visitors and locals.

Ngai Tahu has a vision of creating this area as a significant place for mahinga kai. They would like to bring in a more cultural feel to the area and show the Maori connection to the Lake. It is a great opportunity to enhance awareness about the biodiversity and cultural values of the Lake.

R17- SILVERSTREAM

Silverstream is a tributary of the Selwyn River/Waikirikiri and flows into the Selwyn at Coes Ford Reserve. The site is part of Coes Ford reserve. The catchment is an intensively farmed area that has been farmed for several years. The catchment contributes significant nutrient and sediment run off downstream of the confluence. The water quality in the tributary has remained poor over the years. Upstream at Chamberlains Ford, the water is great while downstream at Coes Ford water quality is poor. Silverstream is the waterway that enters the Selwyn River between those 2km stretch and it has been identified as the most significant polluter in the lower catchment.

Previously, ECan through its Living Stream Programme had done a small planting here with a Streamcare group around the area. They noticed this restoration work did not improve the water quality and through the process the interest was lost in the project. Silverstream is identified as one of the priority areas in WET's riparian restoration programme. Therefore, there were future plans to get restoration underway at this site. This site was also in close proximity to Coes Ford. WET got in contact with various groups to restart the project and to get the required funding. SDC, ECan and the local residents were keen for some work to be done over there. ECan aided in the removal of willows and SDC would fence the area to protect the planting from damage. WET did the initial planting in September, 2010. There were 1,502 native plants planted. WET will continue the maintenance of the plants, which would be funded by Coes Ford Management Committee under SDC, until they are able to self-support. Once again, this project is an example of a collaborative effort between different agencies. Support was provided in different ways but each contributed to the whole effort.

R18 & 19 -SKILLING'S/ LEESTON STREAM, STAGE 1 AND STAGE 2

Leeston Stream is a classified drain on private land belonging to Murray Skilling. The land was used for grazing. The stream flows to the Lake through the Tramway Reserve. It also joins up with Harts Creek at the lower end before flowing out to the Lake.

Previously, the site was an overgrown mess of gorse and other weedy plants. The Skillings decided to clear this area and put a fence there. The Trust got involved at this point. They have been doing work at the Tramway Reserve which is adjacent to this site. They approached the Skilling and suggested that if he moves his fence back a little they can do some planting there. This started up the riparian restoration work at this site. Murray Skilling fenced two sections of Leeston Stream upstream and WET did the planting. WET was interested in this site as it offered an opportunity to continue the work they have been doing at Leeston Stream in Tramway Reserve. The second stage initiated as a request from the land owner.

The first stage of planting was done in September, 2009. There were 7,705 native plants planted, with a row of *Carex secta* on one bank and a strip of native species on the other. There was also some planting done on the banks of a small tributary of the stream. A group of students from St Andrews College provided support to the first stage. These students installed cages in the plantings in November, 2009.

The second stage of planting was done in spring, 2010 and it was done up to the road. There were 2,645 *Carex secta* planted in double rows. It was hoped that this species would provide shade to the waterway and thus prevent growth of invasive weeds, reducing the need for mechanical maintenance. Murray Skilling stated that normally they have to take the excavator and clean the stream annually as it becomes overgrown with weeds. There is at least 2 years of maintenance to be done at the two sites. This site provides an example of collaboration with private land owners. The owner of this land was interested in the riparian restoration because of the work being done by WET at the Tramway Reserve as well as the work done at Harts Creek.

R20- STONES DRAIN

This is a roadside drain on McDrury's Road. It is envisaged that the establishment of native riparian vegetation would stabilise the banks, create shade that can prevent weed growth and maintain access for maintenance.
Environment Canterbury prepared the site which included clearing and rebattering of the banks. There were 250 *Carex secta* planted in a single row along the banks.

R21- TRAMWAY RESERVE

This site was a small local reserve at the end of Leeston Creek/Stream. This area was a part of the indigenous wetland, the Lake Ellesmere. However, willows has infested the area and replaced the native vegetation. There was high biodiversity which was lost there, but remnants can still be seen among the willows. Riparian restoration work is being done at Leeston Stream which flows through the reserve.

The site was chosen because of its high potential biodiversity values. It is expected that in the long term riparian restoration could aid to regenerate the wetland ecological functions of the area such as filtering of nutrients. Waihora Ellesmere Trust saw an opportunity to undertake riparian restoration work at this site.

There was already a group, Tramway Reserve Trust, which was operating in this area. This group was formed as part of resource consent by SDC to discharge excess treated water from Leeston Sewage Treatment into Leeston Stream (to date, the need has not arisen to do so). Riparian restoration was one of the mitigation actions included in the consent. Tramway Reserve Trust has been doing riparian restoration work since 2005. However, they have not been undertaking any major plantings and they had some funding available for this. Waihora Ellesmere Trust saw an opportunity to provide expertise and the drive to take on riparian restoration work at the site. Therefore, there was a partnership formed between WET, Tramway Reserve Trust and Department of Conservation. The funding is provided by Tramway Reserve Trust together with various other funding sources.

The site was cleared from willow, sprayed and planted with native plants along the stream. There was also a walkway established. The first plantings were done in 2008. It is hoped that in the future small projects like this would help to regenerate the lost wetland areas.